SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MARCH 1912.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MARCH 1912.

GENERAL PHYSICS.

251. *Interferometer Barograph for recording small Pressure-changes.* **A. C. Crehore and G. O. Squier.** (Mount Weather Observatory, Bull. 4. pp. 115–120, 1911.)—To the top of the uppermost of a series of eight standard aneroid cells as used in an ordinary aneroidograph is attached, in a horizontal position, a flat glass plate silvered on its upper surface. The plate rises and falls with decrease and increase of pressure respectively. Just above and parallel to it is fixed a similar plate, thinly silvered on its under side, and at such a distance from the former plate that interference bands of light are produced by a mercury-vapour lamp arranged above the plates. The light in which the bands are formed is passed through a shutter provided with a slit normal to the motion of a long strip of photographic paper, made to travel lengthwise by clockwork, so that a continuous record of the bands is obtained on the paper. In this way extremely small relative motions between the plates, and therefore the small changes of pressure which produce them, are clearly recorded, for a change in the distance between the plates of one-half the wave-length of the light used causes such a motion of the system of bands that each band moves into the position previously occupied by the one adjacent to it. The resulting trace is very similar to a longitudinal section along the trunk of a pine-tree, the bands taking the place of the sections of the layers of growth of the trunk and forming a series of closed curves along the middle of the trace if oscillations of pressure are taking place. By noting the positions at which bands appear and disappear along the middle of the record, a diagram showing the variation of pressure with time in the ordinary way can be prepared. The magnification obtained is approximately 50,000 times. The variations of pressure shown are so minute that a very open time-scale is required, and in the examples given 6 in. of record represent 1 minute of time. One of the illustrations shows 5 distinct waves of pressure occurring in a minute. R. C.

252. *New Seismometers.* (Engineering, 93. pp. 7–10, Jan. 5, 1912.)—A special equipment has been installed at Bochum for the continuous registration of natural and artificial earthquakes (produced by traffic, machinery, blasting, &c.), primarily with the intention of providing information in connection with the mining occupations of the district. The equipment consists of three astatic Wiechert pendulums, two for horizontal and one for vertical movements. Some interesting curves are reproduced, showing the disturbances produced by a pile-driver at a distance of 88·5 m., and by the bursting of a projectile about 1500 m. (1 mile) away. C. P. B.

253. *A Vector Calculator.* **F. Addey.** (Elect. Rev. 70. p. 156, Jan. 26, 1912.)—The calculator enables us to write a vector $R\angle^{\theta}$ in the form $a + jb$ at once, or *vice versâ*. It consists of a 10-in. square on a sheet of xylonite. The sides of the square are divided into inches and tenths, and lines are drawn as in sectional paper. A strip of transparent celluloid is pivoted to one corner O of the square, and a line ruled on it is also divided into inches and tenths. A quadrant of a circle having its centre at O is also constructed. For rough work sectional paper can be used, but for a permanent calculator xylonite is much to be preferred. A. R.

254. *Relativity Model.* **H. Rohmann.** (Phys. Zeitschr. 12. pp. 1227–1230, Dec. 15, 1911.)—Describes a model to illustrate the principle of relativity by means of scales of different sizes (about as two to three), each being provided with dials. Then as one scale is moved with respect to the other the local times are suitably indicated on the respective dials. The model is fully explained by aid of plan, elevation, and perspective view and the corresponding theory developed. E. H. B.

255. *Electric Plane of Reference.* **A. Guillet.** (Comptes Rendus, 158, pp. 1187–1140, Dec. 4, 1911.)—Two slides run on a bed. One slide carries two similar coils (BB), the other carries another coil (*b*). Coils BB are separated by any desired distance. Coil *b* has its axis coinciding with the common axis of BB. If a current be regularly made and broken in BB, the induced currents in *b* will depend on the distance between the slides, and for one position will be *nil*. Using a suitable and sensitive galvanometer it is found possible to bring coil *b* with great exactness to any required place, called the electric plane of reference. This principle can be applied to the measurement of length. P. E. S.

256. *Measurement of very small Gas Pressures.* **C. F. Hale.** (Amer. Electrochem. Soc., Trans. 20. pp. 248–258, 1911.)—When studying phenomena at very low pressures, manometers not dependent upon the use of mercury are most useful. Several attempts have been made to construct such instruments, and one here described is a modified form of the manometer originally suggested by v. Pirani. It depends for its ability to measure pressure upon the fact that at low pressures the heat conductivity of gases is a function of the pressure. With the most sensitive arrangement described by v. Pirani it would scarcely be possible to follow with accuracy pressures lower than 0·0001 mm., but the sensitiveness can be greatly increased, so that by the arrangements now indicated reliable measurements of pressure down to 0·00001 mm. are obtained. A method is described by which the resistance manometer can be calibrated, and by experiments in air and hydrogen it is found that the calibration must be performed in the gas in which it is to be subsequently used to indicate pressure. A. E. G.

257. *Measurement of Hydrostatic Pressures up to 20,000 Atmospheres.* **P. W. Bridgman.** (Amer. Acad., Proc. 47. No. 11, pp. 321–346, Dec., 1911.)—Describes two methods of measuring very high pressures; the one by direct mechanical means, the other by utilising the variation of electrical resistance of manganin under varying pressure. In the direct method a piston of 0·125 in. diam. moves within a nose-piece which protudes into the pressure cavity. Thus the nose-piece is subjected to external pressure which lessens the diameter of the bore and prevents undue leakage between piston and nose. The correction for distortion of piston due to end and side pressures is determined. The packing arrangement between nose-piece and pressure vessel is new, and consists of a soft-steel conical annulus forced down over a hard steel cone. By this device pressures up to 18,000 kg./cm.^{2} can be realised. At high pressures the piston is liable to stick, partly because of the contraction of bore of the nose-piece, and partly because the viscosity of the liquid increases with increasing pressure. The author finds glucose, thinned by a mixture in equal parts of glycerine and water, to work best. The force on the piston is measured by deflection of springs, which are in the form of Belleville washers and have no external frictional resistance. The deflection is made observable by mirror apparatus. Curious hysteresis effects occur in these springs, and a semi-automatic device is used to correct this, so that readings may be taken to 8 kg./cm.^{2}—the limit of sensitiveness of the apparatus. There appear to be no after-working or recovery effects in the springs, yet the stiffness coefficient varies with time and must be determined prior to an experiment. Using this gauge, the author determines the variation of resistance of manganin up to a pressure of 12,000 kg./cm.^{2}. The variation appears, within the limits of experimental error, to follow a linear law, and it is suggested that extrapolation up to 20,000 kg./cm.^{2} is justified. The resistance-pressure coefficient of manganin varies with the history of the specimen; for annealed manganin the coefficient is about $2{\cdot}10 \times 10^{-6}$ ohm per kg./cm.^{2}, and for hard-drawn manganin about $2{\cdot}80 \times 10^{-6}$ ohm per kg./cm.^{2}. Diagrams illustrate the novel features of the apparatus. [See also Abstract No. 601 (1909).] H. S. R.

258. *Liquid and Solid Mercury under Pressure.* **P. W. Bridgman.** (Amer. Acad., Proc. 47. No. 12. pp. 347–438, Dec., 1911.)—The object of the paper is to present for the liquid and solid phases of a substance data corresponding to the data already collected for gas and liquid phases of many substances, and from which have resulted important theories of molecular structure of gases and vapours. On account of experimental difficulty this has not yet been done, the fundamental question as to the existence of a critical point for liquid-solid states analogous to that for vapour-liquid states being still unanswered. Mercury is chosen as the liquid because its compressibility and thermal dilatation are comparatively small and the internal structure is simple; no polymerisation sets in and no allotropic modifications complicate the freezing curve as in the case of water. The highest range previously used is 8000 atmos., and was attained by Amagat, who used glass piezometers. The author uses piezometers of good Bessemer steel, by which the troublesome correction for distortion is much smaller. By annealing the steel it is made so homogeneous that the correction is highly accurate. The accuracy of all the authors' observations is 0·1 per cent. The method employed is a modification of that used by Aimé in 1842, and consists of weighing the water which bubbles into an inverted narrow-necked vessel full of mercury under pressure. The compressibility of water and steel are involved in reducing the results, and the determination of these forms subsidiary experiments. If the pressure is carried too high the water freezes with sudden decrease of volume. This is surprising in the light of Tammann's curve, which gives no evidence of the existence of ice above 0° C. The author finds there are other forms of ice besides those observed by Tammann; one of these is stable at room temperatures. On account of this the investigation of the *pvt* relation for mercury cannot be brought up to the freezing curve, but by utilising the unstable region for water the freezing curve of mercury can be comparatively closely approached. The piezometers employed have volumes of 1 or 2 cm.³ for water, and 3 or 4 cm.³ for mercury. The pressures are measured by a direct gauge [see preceding Abstract] and the compressibility of the steel is deduced from experiments on a rod of the same material, 29·95 cm. long, subjected to uniform hydrostatic pressure. The compressibility of the steel from 0 to 10,000 kg./cm.² at 10° C. is $0{,}0_6583$, and at 50° C. is $0{,}0_6601$ per kg. cm.², from which the temperature compressibility coefficient is determinate. The compressibility (C) of mercury at 0° at 22° is determined, and the results are shown completely in tables and curves. A few of the values are:—

Kg./cm.²	$C_{0°}$	$C_{22°}$
1000	0·00374	0·00389
2000	0·00739	0·00766
3000	0·01095	0·01130
4000	0·01439	0·01483
5000	0·01769	0·01820
7000	0·02393	0·02454
10,000	—	0·03297
12,000	—	0·03787

Of all previous workers, the only ones accurate enough for comparison are Amagat, de Metz, and Richards, whose values show good agreement. Using the results of Callendar and Moss on the dilatation of mercury, the *pvt* surface is mapped out. Transition from liquid to solid is investigated, the freezing curve and the alteration of volume being determined. Three methods are used: (1) Change of resistance during change of state—this merely gives freezing curve. (2) Tammann's method gives melting pressure and change of volume. (3) A single accurate determination of change of volume during freezing at atmospheric pressure is made. The relation of freezing temperature to pressure is expressed in tables and curves. The relation is nearly linear, being slightly curved towards the pressure axis. The best mean straight line yields a variation of 197·1 kg./cm.² per 1 deg. rise of temperature. The freezing curve begins with a slope of 196·5 kg./cm.² per 1 deg., and the variation from this tangent line is + 5¼ kg./cm.² at 6000 kg./cm.², and + 65 kg./cm.² at 12,000 kg./cm.². An unsuccessful attempt to determine the heat of transformation (by dissolving Cd) is described. The fact that it is impossible to superheat a crystalline phase with respect to the liquid phase, although the liquid may be sub-cooled with respect to the solid, seems to hold at high pressures. A chart is given showing the isothermals for mercury on the *pv* diagram for pressures up to 12,000 kg./cm.², and temperatures from −38·85° to + 20° C. Tables of quantities of thermodynamic interest are given, including dilatation, change of specific heats, adiabatic compressibility, heat of compression, and change of internal energy along the isothermals and adiabatics. The latent heat of freezing is given, and at high pressures there is a change in the trend of the latent heat which invalidates Tammann's argument for the existence of a maximum. The author thinks that if either a maximum or a critical point exist for the transition solid to liquid it could not well be at less than 50,000 kg./cm.^{2}. The author claims to give improved values for the density of solid mercury at $-38{\cdot}85°$ C., for the specific heat of the solid, the electrical resistance of the liquid up to the freezing pressure, the resistance of the solid under various pressures, and the pressure and temperature coefficients. [See also Abstract No. 602 (1909).] H. S. R.

259. *Measurement of Large Forces in the Testing of Materials.* **A. Martens.** (Preuss. Akad. Wiss. Berlin, Ber. 53. pp. 1132–1141, 1911.)—The Royal Testing Depôt at Gross-Lichterfelde has a set of high-grade cylindrical steel specimens calibrated and suitable for loads up to 500 tons. Calibration is carried out with a Martens mirror extensometer reading accurately to 10^{-6} cm. The specimens are specified to give the same elongation from 1 to 10 tons as from 90 to 100 tons. In using these specimens to calibrate testing-machines highly skilled observers are required to use the mirror apparatus. Further, it has been noticed that the beams of testing-machines suffer considerable damage from the heavy stresses at fracture of test-pieces under big loads. Accordingly the author has devised a machine in which the load comes on the ram of a cylinder, transmitting the pressure to water through a diaphragm. The hydraulic pressure is registered on a gauge, and, multiplied by the effective area of the ram, gives the load. The effective area can be determined by calibrating pressure-gauge readings, with a standard steel specimen and mirror apparatus. Even for small loads such a machine is accurate to ± 0·5 per cent., and an observer of average skill can take the gauge readings required. As pressures above 200–300 atmos. are impracticable in this apparatus, inordinately large diameters would be necessary for very high loads. For such loads the principle employed is to attach one end of a calibrated standard to the cylinder and the other end to the ram. Any strain due to loading then causes a change in the cubic contents of the cylinder, which can be accurately determined with a mercury index or similar device, and which also gives a direct measure of the stress in the standard. A description is given of such a machine devised by the author to measure forces up to 3000 tons; the machine stands on one corner of a small table. C. A. M. S.

260. *Dependence of the Breaking Strength upon Temperature.* **F. Hauser.** (Deutsch. Phys. Gesell., Verh. 13. 21. pp. 906–920, Nov. 15, 1911.)—The advent of heat engines led to the investigation of the elastic behaviour of iron and steel at high temperatures. It appears that the strength of iron reaches a maximum under heat treatment of about 1·5 times its value at 20° C. and falls off on further heating. Experiments are here recorded on hard rubber, wax, rosin, and rosin mixed with wax. The specimens were in the form of bars supported at each end and loaded to destruction at the centre. Great care was taken to ensure even temperatures by immersion in water, and to secure even loading over the cross-section by means of an elaborate apparatus. In drawing conclusions, the author selects the most consistent set of results, pointing out that local faults or accidental uneven loading will give unfairly low breaking strengths. It is pointed out that the tensile strength is less than the compressive, hence the fibres under max. tensile stress fail first, cumulatively upsetting the assumption of linear stress-distribution. For hard rubber the criterion of a good break was when the lower half of the section appeared rougher and duller than the upper, and the lower half showed a structure of rays starting from a point at the centre of the lower surface, this point not appearing smooth and polished. The strength of hard rubber is independent of the temperature from 0° to 25° C.; thence it falls off steadily. Wax showed a granulated fracture, which, in a good case, was somewhat finer and more clear on the tension half than on the upper. Rosin showed a fracture like that of rubber with the distinctions more marked. Great care was taken to select specimens of consistent composition and colour. Overheating in preparation tended to affect the strength and colour. Curves of variation of strength with temperature are shown for pure rosin, rosin with various proportions of wax, and pure wax. The curve for rosin rises fairly rapidly till 80° C.; it then falls off, at first suddenly and then more slowly. Wax falls off from the commencement, at first slowly, then more rapidly. With 6 per cent. wax the curve hardly rises at all, and then falls as for pure wax from 5° C. The strength of rosin with 6 per cent. wax is less than that of pure wax up to 20° C., whilst pure rosin is stronger than wax from 6° C. onwards, rising to a maximum at 80° C. and then decreasing. The temperature corresponding to the maximum strength of rosin is that at which the coefficient of expansion changes from a rapid to a slower rate of increase. The influence of small additions of wax is very greatly to weaken rosin. C. A. M. S.

261. *Experiments on the Stress Distribution in Crane-hooks.* **E. Preuss.** (Zeitschr. Vereines Deutsch. Ing. 55. pp. 2173–2176, Dec. 30, 1911. Extract.)—The object of these experiments was to determine how far the actual stress distribution over the cross-section of a crane-hook agrees with that predicted by the ordinary theory. Hooks to carry 5 and 10 tons respectively were tested. The stresses were measured at various points across the horizontal normal section in the plane of the centre of the hook, by means of a modification of Martens' optical extensometer. Measured stresses are compared with those calculated from the formula $\sigma = -P\eta/xF(r+\eta)$, where P is the load, η the perpendicular distance of the point from the neutral axis, F = cross-sectional area, r = radius of curvature, x = const. = 0·0762 for the 10-ton and = 0·0692 for the 5-ton hook. The results show that the max. tensile stresses as measured are 27·2 per cent. above in one case, and 5·5 per cent. less in the other, than those calculated. It must, however, be remembered that the sections of the two hooks were not geometrically similar, and that the relations between the hook's radius and the height of the horizontal section were not the same. The line of zero stress does not pass through the centre of gravity of the section, being nearer the hook. It is suggested that this is due to a concentration of stress on the load side, which deviates least from the line of the shank. These hooks stood 90 per cent. overload without overstraining. C. A. M. S.

262. *The Acceleration of Impulsive Waves along Filaments.* **Jouguet.** (Comptes Rendus, 153. pp. 933–936, Nov. 13, 1911.)—The present paper extends to the case of impulsive waves along filaments, theorems already proved for impulsive waves in gases [see Abstracts Nos. 868 and 1204 (1906)]. He uses the notation of Roy, who discusses the same problem [see Abstracts Nos. 486B and 723B (1911)]. The following rule is proved mathematically. "If immediately behind the front of the wave, the density of an element varies in the same sense as the direction of the propagation of the wave, the discontinuity propagated goes on getting more pronounced and the velocity goes on accelerating. In the contrary case the inverse result holds." A. R.

263. *On the Propagation of Waves of the Second and Third Kind in Filaments.* **Jouguet.** (Comptes Rendus, 153. pp. 1062–1064, Nov. 27, 1911.)—The author continues his mathematical investigations [see preceding Abstract]. He proves that provided the discontinuity be not too pronounced, the velocity of an impulsive wave of the second kind is less than the velocity of the transversal waves of acceleration in the medium which follows it, and greater than the velocity of the transversal waves of acceleration in the medium in front of it. He also proves that immediately behind a wave of this kind, if the density of an element varies in the same sense as the direction of motion of the wave, the discontinuity propagated by the wave goes on increasing, and its velocity accelerates. A. R.

264. *Resistance on Sphere oscillating in a Viscous Fluid.* **G. F. McEwen.** (Phys. Rev. 33. pp. 492–511, Dec., 1911.)—An experimental research which may be summarised thus :—The hydrodynamical theory of a frictionless fluid failed to account for the experimental results of the pendulum observations of Bessel, Baily, and Dubuat, and this fact led Stokes to apply the theory when the fluid friction was taken into account. The prediction based on this theory agreed well with the experiments on pendulums vibrating in gases, but when the fluid was water, instead of gas, the agreement was not so good. This discrepancy is, however, attributed to the difficulty of the experiment rather than any failure of the theory. To avoid the rapid diminution of the oscillations when in water, forced oscillations were then used, so that the viscosity of water could be found by the sphere's oscillations in it, as intended by Stokes. E. H. B.

265. *Stokes' Law for Spheres moving in Liquids and Limitations by Slip and Inertia.* **H. D. Arnold.** (Phil. Mag. 22. pp. 755–775, Nov., 1911.)—An experimental research to test the limitations on Stokes' law due to slip and inertia terms, the chief conclusions being as follows :—It is possible to make metallic spheres sufficiently small and uniform in density and in surface texture to allow of the verification of Stokes' law in the less viscous oils. One of these spheres may be used instead of the capillary tube method to test the rate of variation of viscosity with temperature or with pressure, with probably greater accuracy, and certainly with greater ease and rapidity. Ladenburg's correction for the effect of the walls of the fall tube is independent of the viscosity, and holds for spheres of radii not greater than one-tenth the radius of the tube. Stokes' law, with the above correction, holds in the less viscous liquids to within at least 0·5 per cent. The inertia terms begin to have an appreciable effect when the radius of the sphere is about 0·6 of the critical radius. The coefficient of sliding friction at the surface of the solid spheres used is certainly greater than 5000, and probably greater than 50,000. The theoretically derived formula involving the coefficient of sliding friction holds in the case of complete surface slip. The slip at the surface of a bubble of gas rising through a liquid may be either approximately zero or infinite. This can be explained from the film-forming properties of the liquids, and hence we may explain the irregularities of previous experiments on the rise of air-bubbles. A consideration of the erosion at the surface of an air-bubble leads to the possibility of a new method of determining the relative spheres of molecular attraction in liquids. E. H. B.

266. *The Development of a Function in a Series of Exponentials.* **A. Leauté.** (Comptes Rendus, 154. pp. 28–30, Jan. 2, 1912.)—In a previous paper the author [see Abstract No. 128 (1912)] has shown how to find the

value of this series in the limiting cases. He applies the results to the solution of the equations of power transmission. In particular he considers the special problem of the 100,000-volt transmission of power for the Turin Exhibition. A. R.

267. *Longitude of Paris–Bizerta by Wireless Telegraphy.* **H. Renan.** (Comptes Rendus, 153. pp. 1211–1213, Dec. 11, 1911.)—Observations of the difference of longitude between Paris and Bizerta, Tunis, were made during April, 1911, by Lancelin and Tsatsopoulos, the necessary communication between the two stations being established by wireless telegraphy. From the Eiffel Tower signals were sent to both stations, and were recorded by telephones by each observer, who was also able to hear the clock-beats. Return signals were also sent out from Bizerta. The method of coincidences was employed for greater accuracy, and the signals accelerated so that 90 signal intervals occupied 89 sidereal seconds, giving two coincidences in 3 min. Two series of determinations are quoted—one of 7 nights with a range of 0·060 sec., the second of 5 nights with a range of 0·047 sec. A determination of the time of transmission of the signals gives it as 0·007 sec., showing the velocity to be practically equal to that of the velocity of light. C. P. B.

268. *Electrically-produced Water-ripples.* **F. Palmer, Jr.** (Phys. Rev. 33. pp. 528–530, Dec., 1911.)—Pfund has shown that the simple method of producing water-ripples by means of the discharge from an induction coil can be made use of in the study of optical phenomena [Abstract No. 576 (1911)], and he was able to photograph some cases of interference and diffraction. His method has the disadvantage that only one or two persons can see the phenomenon at the same time, and further, the source of illumination is very weak and the ripples very small. A modification of this experiment is now described, to which none of the above objections apply, and in addition, the experiment on ripple refraction through on oil-drop, which Pfund was unable to photograph, can also be readily demonstrated. A. E. G.

269. *Experimental Investigation of Gibbs' Thermodynamical Theory of Interfacial Concentration in the Case of an Air-Water Interface.* **F. G. Donnan** and **J. T. Barker.** (Roy. Soc., Proc. Ser. A. 85. pp. 557–573, Nov. 30, 1911.)—The surface-tensions and surface-concentrations at an air to water interface were experimentally determined in the cases of solutions of nonylic (pelargonic) acid and saponine. The surface-tension of aqueous solutions of nonylic acid is extraordinarily sensitive to minute changes of concentration, and afforded a practicable method of measuring the increase of concentration produced by air-bubbles passing upwards through a solution provided with a series of traps to prevent mixing of the contents. In the case of very dilute solutions the adsorption (surface-concentration) at the surface of the air-bubbles was found to be of the order of 1×10^{-7} gm. per cm.^{2} for nonylic acid, and of the order of 4×10^{-7} gm. per cm.^{2} for saponine. With solutions of sodium glycocholate, Congo red, and methyl orange, Lewis found the adsorption at an oil to water interface to amount to about 5×10^{-6} gm. per cm.^{2}. The values for the adsorption of nonylic acid and saponine agree as to order of magnitude with the values calculated from Gibbs' equation. Considering the experimental difficulties, the agreement affords a satisfactory verification of Gibbs' theory of surface-concentration for an air to water interface. T. M. L.

270. *Temperature- and Pressure-changes in the Rocky Mountains.* **A. J. Henry.** (Mount Weather Observatory, Bull. 3. pp. 201–225, 1910, and 4. pp. 103–114, 1911.)—The vertical gradient of temperature between summit and base stations in the Rockies varies considerably on different days and at different times of the same day. From Nov. 1, 1909, to March 31, 1910, the gradients ranged from −0·48° to + 1·42° C. per 100 m., the gradient being reckoned positive when temperature falls with altitude, negative when it rises. Under the former gradient the air-column is in very stable equilibrium; under the latter it is essentially unstable, since the gradient is in excess even of the dry adiabatic rate (1° C. per 100 m.). The daily variation in the gradient as shown by hourly means gives a maximum of 0·81° C. per 100 m. at 1 and 2 p.m., and a minimum of 0·50° at 5 a.m., the mean value being 0·66° per 100 m. Changes of temperature at the summit and base stations are fairly synchronous as a rule. There are some curious exceptions; as for example, in winter, when pressure rises it often happens that temperature falls rapidly at the base station, but rises at the summit station, until temperature at the top is higher than at the base. The corresponding variations of pressure show the effect of the anomalous temperature-changes, and indicate how uncertain becomes the reduction of pressure to sea-level if average values of the temperature gradient are assumed to hold good, and the height of the station is considerable. The question as to whether a cyclone is colder than an anticyclone is answered in a doubtful affirmative from the Rocky Mountain observations, although results from kite and balloon ascents support this reply in a more decided way. Uses to which the observations from the mountain stations can be put by the local Weather Bureau forecaster are pointed out; for instance, on the approach of a cyclone the usual rise of temperature takes place at the upper station before the lower. R. C.

271. *Relation between Atmospheric Pressure and Wind.* **J. W. Sandström.** (Mount Weather Observatory, Bull. pp. 275–346, 1911. Translation of paper read before the Royal Swedish Academy.)—In this paper the author first shows that for uniform steady frictionless motion the wind velocity will be proportional to the pressure gradient, and a table is given by means of which the velocity may be deduced from the gradient. He next takes Guldberg and Mohn's assumption that frictional resistance acts in the line of the velocity reversed, and from the pressure and wind distribution shown on the synoptic weather chart for Northern Europe for Oct. 28, 1901, finds that on this assumption the air-particles must have been subject to an acceleration of 0·113 cm./sec.^{2} or 100 m. per sec. per 24 hours along the line of the pressure gradient. As subsequent maps showed that the wind conditions were approximately steady, the assumption which led to the above result must be erroneous, and the author is therefore led to assume that the frictional resistance acts at an angle β with the line of motion. From the data on the chart the mean value of β over the area considered is calculated to be 88° to the right of the line of motion and the frictional retardation 0·166 cm./sec.^{2}. (Wind velocity 8·8 m. per sec.) This value is nearly 8 times as large as that found on the erroneous assumption given above. From this it is assumed that the friction must be composed of two separate forces: (1) the friction of the air on the ground surface, and (2) the friction of the upper currents on the lower. The author then, from the data on the above-mentioned chart, deduces equations relating wind velocity with pressure gradient and frictional acceleration with pressure gradient, and assumes these to be approximately normal values for Northern Europe. Having obtained these working equations, the author considers the course of events when a pressure gradient arises over a district previously occupied by still air, and shows that instead of settling down to steady motion the air-particles will follow a sinuous path of the sine-curve type. It is then shown that the wind distribution on weather maps often gives evidence of this type of motion, and different classes of sinuous curves which actually occur are illustrated. The above cases all deal with pressure distributions showing straight isobars. The author next briefly considers the paths of air-particles when the isobars are curved, on the assumption that the angle between the wind and isobar is the same as that found previously with straight isobars, and points out that with certain defined distributions ascending and descending currents are to be expected, giving rise in the one case to wet, and in the other to fine, weather. A thunderstorm which passed over Sweden on Oct. 4, 1908, is next considered, and a calculation made showing that energy was being transformed from a thermal to a dynamical state at the rate of 232 million horse-power along a length of 200 km. of the storm front. It is suggested that this energy produced the hurricane winds associated with the storm. The paper closes with a reference to N. Ekholm's system of isallobars.

J. S. Di.

272. *Exchange of Heat between the Earth and the Air flowing over it.* **F. M. Exner.** (Akad. Wiss. Wien, Ber. 120. 2a. pp. 181–230, Feb., 1911.)—The primary cause of air motion is the heat imparted to or extracted from the air by the ground. The author's aim is to determine whether this heat is conveyed mainly by conduction and convection, or by radiation. "Cold waves" in America and Russia spread across the country with wave-fronts at right angles to the cold air which displaces the warm air formerly at the surface, with velocities slightly greater than those of the cold winds. No great error is, however, introduced if it is supposed that the front part of a wave is always composed of the same air. For the American cold wave of Jan. 10–14, 1895, the wave-front travelled to the south-east at a rate of about 1000 miles in 24 hours, and the temperature of the front of the wave increased with the time from −25° C. in the north at midnight between the 10th and 11th, to +5° C. in the south at 8 p.m. on the 11th, the relation between temperature and time being nearly linear. Starting from the hypothesis that the rate of increase of temperature of the cold air is proportional to the difference between the temperature of the ground and the cold air, or, since ground temperatures are not sufficiently known, between those of the warm and cold air, it is shown mathematically that temperature-increase of the cold air is eventually proportional to the time, thus agreeing with the facts of the American wave; also, that the computed value of the total increase of temperature agrees fairly well with the actual value. The results show that the hypothesis is justified. The constant K in the equation $dT/dt = K(\theta - T)$ (where T and θ are the temperatures of the cold and warm air respectively, and t is time), which expresses the above hypothesis, is found to be $2{\cdot}8 \times 10^{-5}$ sec.$^{-1}$. Applications to three other cold waves give values for K varying from $1{\cdot}6 \times 10^{-5}$ to $4{\cdot}9 \times 10^{-5}$. Extensions of the theory to the trade winds, to the distribution of temperature in a depression, and to the displacement of temperature extremes from the middle of continents and oceans towards the east on account of prevailing west winds give values for K ranging from 1×10^{-5} to 8×10^{-5}. The agreement between these results is as good as can be expected. Since the transmission coefficient of the atmosphere for long-wave radiation is great, the inference is that conduction and mixing, but not radiation, are mainly responsible for the warming. Observations made at night by different investigators in order to determine the coefficient of radiation, have been used in an equation of similar form to the above, and the values of the radiation coefficient, so determined, give values of the constant corresponding with K varying from $2{\cdot}7 \times 10^{-5}$ to $4{\cdot}2 \times 10^{-5}$, and therefore similar to those found in the paper, although in this case it is a decrease and not an increase of temperature that is considered. The conclusion is that the two coefficients represent the same physical quantity, and hence that what has hitherto been called the radiation coefficient represents in reality a combination of conduction and radiation effects, the latter being probably small. Heat is conveyed to or abstracted from the air mainly by conduction between the ground and the lowest layers, and by convection between the latter and the upper layers, and the value of K depends partly on the extent of the convection, being great if convection is small, and *vice versâ*. [See Abstract No. 586 (1911).] R. C.

273. *Propagation of Cold Waves in European and Asiatic Russia.* **H. v. Ficker.** (Akad. Wiss. Wien, Ber. 119. 2a. pp. 1769–1837, Dec., 1910.)—Sudden temperature-falls of 10° C. and more are not rare in Russia. As a rule the clouds tend to disappear when the cold sets in. Examining the records for the period 1898 and 1902, of all the days of sudden temperature-falls, the author comes to the conclusion that the changes are caused by a real transport of cold air, as in the "cold waves" of North America. In making his analysis he connects all the spots at which the cold sets in at the same time; owing to the immense area with which he deals he has only been able to draw one line for each day. The records are taken from 56 stations comprising also Taschkent and Samarkand in Central Asia, and he has studied about 50 cold waves and drawn 200 charts; in some cases comparative data from Vienna, the Sonnblick, &c., are quoted. He had presumed that North-East Siberia, the "centre of action" (of the winter high-pressure area), would be the chief origin of the cold waves. Such cases seem to be rare, however, and most of the cold waves came from the shores of the Arctic Ocean, both west and east of Nova Zembla. The barometric rise is not greatest where the cooling is greatest, and the rise becomes less marked with increasing distance of the spot from the origin of the cold wave. The waves advance with velocities ranging from about 475 to 700 km. per day, the maximum being 1000 km.; that would mean from 20 to 30 km. (max. 40 km.) per hour, which is the rate at which thunderstorms advance, and from 5 to 8 m. (max. 11 m.) per sec., whilst strong winds travel at 20 m. per sec. and more. H. B.

274. *Height and Temperature of Isothermal Layer at different Latitudes.* **W. J. Humphreys.** (Mount Weather Observatory, Bull. 4. pp. 136–142, 1911.)—Examining the effect of water-vapour on radiation, it is evident, owing to the large coefficient of absorption which water in all its forms has for radiation of long wave-lengths, that the planetary radiation of the earth, to which the isothermal condition is due, originates at a greater or less average altitude in the atmosphere, and at any given altitude, is more or less vigorous according to the amount, distribution, and condition of cloud and water-vapour. From a table given it is seen that the isothermal region becomes higher and colder with decrease of latitude. The point as to whether this result is due to the presence of ozone or water-vapour clouds is discussed, the conclusion being somewhat in favour of the predominating

action of water-vapour. The lower temperature of the isothermal layer at the Equator may possibly be due to the cloaking action of the high cirrus which is so prevalent there. C. P. B.

275. *Amount and Vertical Distribution of Water-vapour on Clear Days.* **W. J. Humphreys.** (Mount Weather Observatory, Bull. 4. pp. 121–128, 1911.)—Measurements of solar radiation vary according to the quantity of water-vapour in the air. Hann's value for the average moisture, commonly used, is the mean of observations on all kinds of days, whereas absolute pyrheliometric observations are usually made on clear days only. The results of all the balloon ascents from the Continent of Europe for clear days, 74 in number, were collected and the humidity values extracted. Ascents usually started at 8 a.m. and lasted from two to several hours according as the balloons were free or captive. Tables and curves show the variation with height up to 11 km., of water-vapour measured in gm. per m.^{3} for each of the four seasons and for the year. The annual curve shows at first a rapid decrease of humidity, the values being 7 gm./m.^{3} at ground-level and 2 gm./m.^{3} at 2½ km. Thence humidity falls off more slowly and is practically zero at 11 km. All the curves show slight departures from regularity at heights varying from 1 km. in winter to 3 km. in summer, where increased humidities are indicated. These heights are just above layers of max. average cloudiness, viz., the cumulus level for the seasons, and the increases are accounted for by the probable presence of clouds shortly before or after the ascent. For cloudless days at any season the thickness in mm. (d) of the water that would result from the condensation of all the vapour above any level is given approximately by $d=2e$, where e is pressure of water-vapour at the level in mm. of mercury. Hann's value for all days, above referred to, leads to $d=2{\cdot}3e$. R. C.

276. *Thunderstorms and Wind Squalls (Böen).* **W. Schmidt.** (Akad. Wiss. Wien, Ber. 119. 2a. pp. 1101–1218, July, 1910.)—The paper deals with 16 months' observations, taken at Vienna by W. Trabert with the author's variograph, and with experiments on heavy (cold) fluids flowing into light (warm) fluids. The author classes thunderstorms with squalls and does not consider the electrical phenomena as really essential. In the experiments he fills a trough, 1·8 m. in length, provided with glass walls, partly with water; a partition wall is in its lower portion closed or opened by sliding a sluice up and down, and coloured liquids of different density (salt solutions, glycerin) are introduced into the trough. When the heavy liquid advances into the lighter liquid, it never does so in the form of a pure wedge; there is always in front of the advancing edge a bulging head, more or less in vortex motion, and immediately behind it a stricture; then follows the wedge. The head corresponds to the core of the advancing squall, which is not a vortex with horizontal axis, however. The analogy between the two phenomena is also quantitative. A squall or thunderstorm arises when cold air penetrates from below into warm air; the velocity of propagation of the storm depends upon the temperature-differences between the two strata, in accordance with the experiments. The stratification before the storm is not, as is often assumed, unstable, but stable; instability can only play a secondary part. H. B.

277. *Distribution of Solar Heat over France.* **J. Loisel.** (Comptes Rendus, 153. pp. 1535–1537, Dec. 26, 1911.)—An attempt is made to form a general expression for the heat distribution over a given area, based on

Bartholi's equation, and an integral is used involving the solar altitude, mass of air traversed, and the calorific intensity as determined by actinometer. This is evaluated for steps of 2° latitude between the limits 42° and 52°. Combining these with the curves of annual variation of heat for the various latitudes, tables are given showing the quantities of monthly heat for the region quoted, and also summaries for the four seasons. All are for clear sky, and under any other condition a subsidiary factor must be introduced.

C. P. B.

278. *Influence of Radiation on the Diurnal Range of Temperature in the Air.* **K. Wegener.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 4. pp. 382–408, 1911.)—Over land the results of kite ascents indicate that radiation effects are responsible for diurnal changes of air temperature near the ground, and that the variations are transmitted to the higher layers by conduction assisted by convection and mixing. Radiation effects in the upper layers are masked by the much larger changes due to conduction, &c. Over the sea the results of numerous observations indicate that the temperature of the surface water shows a small diurnal variation varying from 0·1° C. to 1·6° C., while that of the air shows a larger variation. Reasons are given for doubting the accuracy of the observations of air temperature made at sea under ordinary conditions, and the results of eight kite ascents made by the author from a sailing boat in the Samoa Islands are quoted to show that the diurnal variation of air temperature at the surface is not recognisable over the sea, whereas a diurnal variation at 1000 m. is indicated. The conclusion is that the diurnal variation aloft, which at 1000–1500 m. over Samoa amounts to about 0·5 C., must be occasioned by direct radiation, and some results of kite ascents at Lindenberg are adduced in support of the conclusion. The radiation effects on temperature variations are traceable at Lindenberg only up to about 2500 m., so that they are probably associated with the presence of dust and water-vapour.

R. C.

279. *Studies in the General Circulation of the Atmosphere.* XI. *Radiation from the Sun and Temperatures in the Earth's Atmosphere.* **F. H. Bigelow.** (Mount Weather Observatory, Bull. 3. pp. 229–282, 1910.)—Radiations of short wave-length increase with rising temperatures. The mass of the sun is apparently in violent agitation, and the earth encounters in its orbit relatively hot and cold rays. Some of the rays are scattered, more by multiple reflection from air-molecules, ice-particles, and dust than by absorption, and the percentage of short-wave radiations decreases as the rays penetrate more deeply into the atmosphere. Some energy is absorbed by the rarefied gases, and reappears as heat in the isothermal layer and as electric currents. A further transformation of energy takes place in the lowest strata, where the denser gases and aqueous vapour absorb energy under the production of free ions; as all diurnal and semi-diurnal periodicity disappears 2 miles from the surface, the electric and magnetic phenomena must be caused by transformations occurring in the lowest strata.

H. B.

280. *Radiation Zones of the Earth.* **W. J. Humphreys.** (Mount Weather Observatory, Bull. 4. pp. 129–135, 1911.)—Taking the general effective radiating surface of the earth's atmosphere at an elevation of about 4 km., the action of cloud layers at various other levels is discussed in relation to the degree in which the solar radiation is stopped. The highest cloud—cirrus—is more common during the warmer than during the cooler portions of the day, and more frequent during summer and autumn than at other times of the year. It would thus be expected that it must decrease in frequency and extend from the Equator to the Poles; and this inference receives support from the statement that at Batavia there is almost always a cirrus veil at an elevation of about 11 km. This layer will consume the terrestrial radiation between the clouds and earth, and also tend to lower the temperature of the air outside the layer. It will therefore be possible to make a rough survey of the distribution of radiation by examining the isothermal layer, in which vertical currents are almost non-existent. The resulting values of terrestrial radiation are plotted, showing maximum belts at about latitude 60°, with a minimum at the Equator, and, by presumption, another at either Pole. **C. P. B.**

281. *Photoelectric Measurement of Sunlight.* **K. Bergwitz.** (Phys. Zeitschr. 12. pp. 1111-1112, Dec. 1, 1911.)—After a short reference to previous memoirs on the subject [see Abstracts Nos. 1884 (1907), 958 (1910), 1381 (1911)], an apparatus used by the author is described, consisting of photoelectric cell of special construction, receiving slit, battery, and galvanometer. The observations were made from a balloon on Sept. 17, 1911, and a short table is given showing the readings, with corresponding solar altitudes and barometric pressures. Comparisons are given with the results of other investigators. **C. P. B.**

282. *Terrestrial Meteorology and Solar Radiation.* **F. W. Very.** (Astrophys. Journ. 34. pp. 371-387, Dec., 1911.)—As the solar constant cannot be directly observed, its determination is open to a wide latitude of interpretation. The reformation of the methods for obtaining the value of the constant introduced by Forbes, given a solid rational basis by Langley, and further improved on the mathematical and observational sides by Crova and Savélief, has apparently been relinquished in favour of methods not differing essentially from those of Pouillet. The elaborate researches of Abbot and Fowle, while purporting to be a continuation and perfection of Langley's methods, are in reality a complete abandonment of the essential principle that the radiant energy is not a single emanation, but the sum of an infinity of diverse ones, each with its own separate rate of absorption. The value of about 2 cals. thus given is practically the same as Pouillet's value, if the known necessary corrections are applied to the old work. The present author now adversely criticises the procedure adopted by Abbot and Fowle. One of the weak points in their argument relates to the absorbent power of water-vapour. Also the absorption of terrestrial radiation of great wave-length is overrated, and the solar radiation undervalued. The almost total absence of low-altitude records is to be regretted, and also the dependence on summer observations nearly to the exclusion of winter observations. The author concludes by suggesting a value between 3 and 4 cals. for the solar constant as being more satisfactory. **C. P. B.**

283. *Origin of Ocean Depths.* **W. Trabert.** (Akad. Wiss. Wien, Ber. 120, 2a. pp. 175-180, Feb., 1911.)—Surveys have shown that 36·0 per cent. of the ocean has a depth between 4000 and 5000 m., and 12·1 per cent. between 4600 and 4800 m. Similarly 22·8 per cent. of the land surface has an altitude less than 1000 m., and 10·0 per cent. less than 200 m. An average depth for the ocean is 4300 m., and an average height for the land surface is 560 m.—a difference of nearly 5000 m. At the sea-bottom (say at a depth

of 4800 m.) the temperature is about 0° C., but at the same depth under the land the temperature is about 140° C.

Consider two pyramids, each with its apex at the centre of the earth and base at a depth of 4800 m., one, A, under the sea, the other, B, under the land. On account of the difference of temperature of the bases A will lose heat more quickly and shrink more quickly. Hence the ocean floors should sink. Further, the temperature of A will be lower than that of B by some amount t. And if R is the earth's radius, a the linear coefficient of expansion of the earth's material (say 0·00001), then, if this theory of the origin of the relative levels of continents and ocean floors is correct, $aRt = 5000$, whence $t = 78°$ C. This is a reasonable value for the average temperature difference of the two pyramids since the temperature is the same at each apex and differs by 140° at the bases. The mean temperature-difference should be nearer to 140° than to 0° C. A. D. R.

284. *Earthquake of* **1911**, *November* **16.** **H. Douxami.** (Comptes Rendus, 153. pp. 1100–1101, Nov. 27, 1911.)—Observations made at Lille with two Manka seismographs are detailed. From them the epicentral region is estimated as at a distance of about 480 km. in a direction approximately S. 60° E. The disturbance of the apparatus lasted for about 9 min., and the actual displacement of the ground during the shock varied from 0·2 to 0·8 mm. **E. Rothé.** (Ibid. p. 1192, Dec. 4, 1911.)—The earthquake, as experienced at Nancy, was the most severe since 1855. A self-recording Richard gravity barometer installed in the laboratory there gave a disturbance of 18 mm. in the trace between 9 h. 25 min. and 9 h. 30 min. p.m., while an identical instrument at Paris gave a displacement of only 2 mm. (In each case 5 mm. displacement in the trace are equivalent to 1 mm. change in the height of the mercurial barometer.) The above-mentioned figures indicate how the intensity diminished between Nancy and Paris. A. D. R.

285. *Observations of Jupiter during* **1911.** **E. M. Antoniadi, H. Deslandres.** (Comptes Rendus, 153. pp. 1123–1126, Dec. 4, 1911.)—Details are given, with explanatory drawings in some cases, of the variations of the surface-markings of Jupiter during the period May 22 to July 31, 1911. H. Deslandres points out the possible importance of planetary observations in helping to elucidate the effects of solar variations on the atmospheres of the planets of the solar system. In our own atmosphere our observations are confined to a comparatively small height, and to certain regions of the globe, whereas on a distant planet the whole of the variations of one hemisphere are presented at any one instant. C. P. B.

286. *Photographs of the Planet Venus.* **F. Quénisset.** (Comptes Rendus, 153. pp. 1208–1210, Dec. 11, 1911.)—A series of photographs were obtained at Juvisy during June and July, 1911, which furnish evidence of the existence of definite markings on the planet Venus. On the best of them taken on July 29, during very calm weather, the definition is very clear, and several spots are visible. Lumière plates were employed, with an exposure of 1 sec. It is hoped to find material for a discussion of the rotation period of the planet. C. P. B.

287. *Velocities of Star Groups of different Spectral Type.* **H. A. Weersma.** (Astrophys. Journ. 34. pp. 325–341, Dec., 1911.)—Kapteyn has already shown that the available data indicate that the linear peculiar velocities of stars increase with age [Abstract No. 1090 (1910)]. This has been confirmed by the results of radial velocity determinations by Campbell at Lick Observatory. This probably implies a gradual dissipation of the star streams with advancing age, and is in accordance with Dyson's observation that the stars of Type I. diverge less from the general drift of the streams than the other stars. The aim of the present paper is to utilise the new list of proper motions of Boss for testing the reality of the phenomena. The Harvard classification is used throughout for the definition of the spectral types, attention being chiefly confined to stars of classes A, K, and M. The general conclusion is that more data are required before a definite proof of the reality of the connection can be asserted. C. P. B.

288. *Relativity Statics.* **P. S. Epstein.** (Ann. d. Physik, 36. 4. pp. 779–795, Dec. 7, 1911.)—Develops the statics of the relativity principle, the dynamical aspect having been dwelt upon almost to the exclusion of statics hitherto. [See Abstracts Nos. 1994 (1904) and 1036 (1911).] E. H. B.

289. *The National Experimental Tank.* **G. S. Baker.** (Inst. Naval Architects, Trans. 53. 1. pp. 37–51; Discussion, pp. 51–52, 1911. Engineering, 91. pp. 445–450, and 452, April 7, 1911.) An illustrated description of the tank at the National Physical Laboratory.

290. *Relations between the Density, Temperature and Pressure of Substances.* **R. D. Kleeman.** (Phil. Mag. 21. pp. 325–341, March, 1911.)

291. *Four-dimensional Vector Analysis.* **C. Kraft.** (Acad. Sci. Cracovie, Bull. 3a. pp. 537–541, Oct., 1911.)—Deals with an identity in four-dimensional, vector analysis, and its application in electrodynamics. [See Abstract No. 1215 (1910).] E. H. B.

292. *The Stability Problem in Hydrodynamics.* **C. W. Oseen.** (Ark. för Mat. Astron. och Fysik, Stockholm, 7. No. 15. pp. 1–20, 1911.)—Mathematical.

293. *The Age of the Earth.* **J. Joly.** (Phil. Mag. 22. pp. 357–380, Sept., 1911.)—Discusses the question under the following headings: (1) Age of the ocean derived from solvent denudation; (2) The age from the sedimentary column; (3) Age of the earth by radio-activity.

294. *Resistance of Body moving in a Fluid.* **T. v. Kármán** and **H. Rubach.** (Gesell. Wiss. Göttingen, Nachr., Math. Phys. Klasse, 5. pp. 509–517, 1911. Phys. Zeitschr. 13. pp. 49–59, Jan. 15, 1912.)—A mathematical treatment of the motion of a solid through a fluid with discussion of the mechanism of the resistance thus experienced. The paper concludes by pointing out the analogy to the electromagnetic phenomena of a straight current. E. H. B.

295. *Selenographical Determination of Lunar Formations.* **L. Weinek.** (Akad. Wiss. Wien, Ber. 120. 2a. pp. 551–564, April, 1911.)—An analysis is given for the systematic recording of the positions of lunar formations. C. P. B.

296. *Constants of the Martian System.* **H. Struve.** (Preuss. Akad. Wiss. Berlin, Ber. 48. pp. 1056–1083, 1911.)—A re-discussion is given of the Martian system, including the observations made at the last favourable opposition in 1909. Tables are given showing the position of the planet's axis, polar flattening, and elements of the satellites. C. P. B.

LIGHT.

297. *A Self-registering Photometer.* **M. Samec** and **A. Jenčič.** (Akad. Wiss. Wien, Ber. 119. 2a. pp. 1571–1576, Nov., 1910.)—In researches on the effect of light on plant-life, and on climatic conditions generally, a form of self-registering automatic photometer capable of indicating the intensity of the chemical activity of daylight and its duration is very desirable. The photometer should also be adapted for experiments in balloons, should be unaffected by temperature and moisture, not readily deranged by moderate shock, and as sensitive as possible. The apparatus contrived by the authors consists in a light-tight wooden box with metal cover containing a clockwork device, by means of which light-sensitive paper can be caused to revolve at a uniform rate. By adjusting the clockwork the period of exposure can be varied between the limits of 8 sec. and 5 min., and the mechanism is also so arranged that when the strip of paper is removed the clockwork is automatically wound up for the next experiment. There are two distinct illuminated fields on the paper. One of these records the strength of sunlight as a whole (both direct sunlight and diffused light), the other is arranged to be in shadow, and is therefore only affected by diffused light. By the examination of these exposed portions, and by previous calibration of the light-sensitive paper, the intensity of sunlight can be determined, and information also gained as to the duration of sunshine, and even, in some circumstances, the height of the sun (by deductions from the length of shadow). For use in balloon work a special box, constructed mainly of Al, is used. The apparatus is considered valuable for meteorological studies.

J. S. D.

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298. *Nickeled Glass Reflectors.* **R. W. Wood.** (Astrophys. Journ. 34. pp. 404–409, Dec., 1911.)—It is well known that silver surfaces absorb a large proportion of the ultra-violet radiation which may fall on them, and this fact is of importance in any researches depending on the detection of short wave-lengths in various light sources. Recent experiments suggested the suitability of nickel for the purpose, and the present paper gives directions how to ensure an even deposit of Ni on the surface of a glass mirror. The best results were obtained by an electrical deposition method from the double sulphate of nickel and ammonia. To illustrate the action of the Ni a set of photographs are given, showing the relative amounts of ultra-violet radiation reflected by mirrors of various metallic films. C. P. B.

299. *Reflection of Light from Calcspar near 6·6 μ, the Region of the Bands of Metallic Reflection.* I. **J. Koch.** (Ark. för Mat. Astron. och Fysik, Stockholm, 7. No. 9. pp. 1–16, 1911.)—The author's experiments show that the reflection spectrum of a crystal, either in polarised or unpolarised light, depends very largely upon the crystallographic orientation of the reflecting surface and upon the situation of the principal section relatively to the plane of incidence. They clearly indicate that, even in cases where the reflection maxima corresponding respectively to the ordinary and extraordinary rays have been determined for one special section (parallel to the axis) of a uniaxial crystal, it by no means follows that the form of the reflection curve for any other section is given thereby. The results may have some bearing on the question of comparison of crystals which have the same chemical composition, but differ axially. A. E.

300. *Spectre of the Eiffel Tower.* **A. Chauveau.** (Comptes Rendus, 153. pp. 1048–1054, Nov. 27, 1911.)—The writer describes a curious phenomenon observed by himself over the Champ de Mars in Paris during the great Exhibition. This was the appearance of a replica of the tower apparently projected on the somewhat foggy atmosphere surrounding the summit of the tower. He concludes that it was not a virtual image produced by mirage reflection, but was a shadow projected on the fog, just as occurs in the well-known Spectre of the Brocken. C. P. B.

301. *Refractive Indices of Gases under High Pressures. I. Dispersion of Hydrogen.* **L. H. Siertsema** and **M. de Haas.** (Konink. Akad. Wetensch. Amsterdam, Proc. 14. pp. 592–603, Jan. 24, 1912.)—An interference method was employed to find the dispersion constants of hydrogen for various pressures up to about 80 atmos. It was found that the dispersion constants were the same at all the densities used. The following table compares the results with those of other experimenters:—

λ.	Mascart.	Perreau.	Scheel.	Hermann.	Koch.	Cuthbertson.	Siertsema and de Haas.
0·644	0·9962	0·9927	0·9939	0·9924	0·9984	0·9930	0·9928
0·546	1	1	1	1	1	1	1
0·509	1·0030	1·0041	1·0034	—	1·0038	1·0037	1·0040
0·472	—	1·0090	1·0074	—	1·0085	—	1·0088
0·436	—	—	1·0125	1·0114	1·0152	—	1·0152
0·405	—	—	—	—	—	—	1·0219

The results can be expressed by the formula—

$$C = (n-1)/(n_s-1) = 0{\cdot}97504(1 + 0{\cdot}007387/\lambda^2 + 0{\cdot}000089/\lambda^4).$$

Good agreement is also obtained between experimental values and values calculated from the Lorentz dispersion formula. Taking only one term of the formula the agreement is still good, and calculations from the formula show the natural vibration of hydrogen corresponds to a wave-length of 0·08708 μ, a value which agrees well with Koch's determination 0·0880 μ, and still better with the value 0·087 μ deduced by Natanson from Perreau's experiments. The work is being continued, and will be extended to other gases. [See also Abstract No. 542 (1903).] A. W.

302. *Indices of Refraction of Mixed Liquid Crystals.* **P. Gaubert.** (Comptes Rendus, 153. pp. 1158–1160, Dec. 4, 1911.)—It was recently shown [Abstract No. 1688 (1911)] that the addition of *p*-azoxyphenetol, with positive double refraction, to cholesterol propionate, with negative double refraction, increased instead of diminishing the double refraction of the latter. This result is in marked contrast with the behaviour of solid isomorphous mixtures and has now been tested in other cases. Addition of isotropic substances showed that a small quantity ($\frac{1}{10}$) of some of these increased the double refraction of cholesterol propionate, benzoate, acetate, and caproate, but that larger quantities (¼) diminished the double refraction. Mixtures of cholesterol esters can be kept in the crystalline-liquid state at much lower temperatures than the pure esters, and then show a much greater double refraction. But when allowance is made for temperature the excess is comparable with that produced by isotropic liquids. Addition of *p*-azoxyanisol and of *p*-azoxyphenetol (positive D.R.) to cholesterol caproate increased the double refraction of the positive phase, practically in accord with the usual law for isomorphous mixtures. A similar increase is produced in the case of the negative phase, an anomaly which the authors explain by suggesting the possibility of an unknown negative phase of *p*-azoxyanisol and *p*-azoxyphenetol. The phenomenon would then be one of isodimorphism amongst liquid crystals. T. M. L.

303. *Refractive Index of Metals.* **P. A. Ross.** (Phys. Rev. 33. pp. 549–556, Dec., 1911.)—The refractive indices of a number of the metallic elements have been determined, three methods being employed, viz. : (1) Measurement of deviation in a prism of the metal ; (2) measurement of interference bands produced by the prisms ; and (3) examination of Newton's rings formed by a lens of crown glass and plates of the metals. The metallic prisms were prepared by depositing the metals on chemically-cleaned glass by means of the kathode discharge from a wire, a thin ribbon of flattened wire giving fairly uniform and regular double prisms. The rate of deposition of such prisms varies greatly for different metals, Cu, Ag, Au, Pb, Pt, and Bi depositing rapidly, Fe more slowly, and Mg taking several days. The results obtained by the three methods are fairly concordant, and are as follows :—

	λ = 630.		λ = 589.		λ = 450.		Newton's Rings for Sodium Light.
	Interf.	Dev'n.	Interf.	Dev'n.	Interf.	Dev'n.	
Cu	0·414	0·40	0·529	0·57	1·005	0·85	Less than 1
Au	0·460	0·35	0·658	0·58	1·094	0·98	Less than 1
Pt	1·94	2·07	1·60	1·75	1·49	1·47	Greater than 1·63
Fe	2·04	2·34	1·86	1·85	1·60	1·55	ditto
Ag	0·461	0·37	0·299	0·28	0·274	0·21	Less than 1
Pb	—	2·4	—	1·94	—	1·8	Greater than 1·63
Zn	—	2·39	—	2·11	—	1·79	ditto
Mg.........	—	0·51	—	0·40	—	0·26	Less than 1
Bi	—	1·78	—	1·95	—	2·25	Greater than 1·63
Ni	—	1·90	—	1·88	—	1·77	—
Al and Sn	—	—	—	—	—	—	Between 1·33 and 1·63

The prism deposited by brass wire gave results practically identical with those for copper prisms, and since the wire from which the prisms were deposited was greyish after the deposition, the Cu may have simply left the Zn behind. W. H. St.

304. *Electric Double Refraction in Artificial Clouds.* **P. Zeeman** and **C. M. Hoogenboom.** (Konink. Akad. Wetensch. Amsterdam, Proc. 14. pp. 558–562, Jan. 24, 1912.)—Investigation was made in the case of some clouds and vapours of the double refraction induced by powerful electrostatic fields. In such clouds the suspended particles play the part of the molecules in the hypothesis of molecular orientation. The experiments prove that in a cloud of sal-ammoniac there is no dichroism, but only double refraction. The light from a Nernst filament was made parallel by means of a lens and polarised in a plane inclined to the horizontal at 45°. The vapour or cloud is placed in a horizontal tube which is put between the polariser and analyser and may contain interior plates connected with the source of electricity. As the double refraction is very small it is observed by special means. A horizontal bar of glass perpendicular to the beam of light is introduced between the polariser and the tube. Near the middle of its length the strip is supported by two small glass cylinders and subjected to a small flexure. It is therefore in a condition of strain and double refraction. Between crossed nicols there is a revival of light, especially near the edges of the bar, while near the middle a horizontal band remains dark. The position of the band is determined by two horizontal wires enclosing it, and disposed close to the bar. If a double-refracting substance, with horizontal and vertical principal directions, is introduced into the beam a motion of the band occurs, upwards or downwards, depending upon the sign of the double refraction. The sensitiveness of the method can be changed within rather wide limits; it is increased by diminishing the loads at the ends of the bar, or by increasing the distance of the supporting cylinders. The absolute value of the amount of double refraction was determined, at least for higher values, by means of a Soleil-Babinet compensator. For very small values of the double refraction a second strip of glass may be used instead of the compensator, and flexure in a suitable direction may be applied to this to restore the field of view to its original condition. The cloud of sal-ammoniac was made in a vessel preceding the observation tube. The HCl and NH$_3$ were introduced under slight pressure after being partially dried. By regulating the ratio of the gases the density of the cloud and the magnitude of the particles could be altered. The cloud escaped into the free atmosphere from the observation tube. The source of electricity was either an electrostatic machine or a transformer allowing potentials between 1000 and 10,000 volts to be used. By dichroism a rotation of the plane of polarisation will occur, and therefore a *fading* of the dark band and not a displacement, such as occurs through double refraction, would take place. The effect obtained with the sal-ammoniac cloud was clearly due to double refraction only, and was nearly proportional to the square of the electric intensity. The sign of the Kerr-effect in the sal-ammoniac cloud is opposite to that in ordinary glass. Further particulars of the experiments are to be given later. Very small specific action was found in the case of large separate crystals of sal-ammoniac.

J. J. S.

305. *Electric Double Refraction in Gases.* **R. Leiser.** (Phys. Zeitschr. 12. pp. 955–956, Nov. 15, 1911. Paper read before the 83. Naturforscherversamml., Karlsruhe.)—The author and Hansen have succeeded in observing in gases the phenomenon of electric double refraction, hitherto observed only in solids and liquids. The magnitude of the effect was only from 0·005 to 0·0001 of that for CS$_2$ in the same electric field. The apparatus was similar to that employed in an investigation of the electric double refraction of liquid organic compounds [Deutsch. Bunsen-Gesell., Abhandl., Heft 4]. The method of measurement was based on a principle adopted by Des Coudes for liquids. In all 21 gases were examined, of which 4, including nitrogen and oxygen, gave no measurable double refraction at a pressure of 2 atmos. The measures show that the Kerr-effect in gases is proportional to the pressure, a law which

holds with great accuracy considering the extreme delicacy of the task, the divergence from a straight line being only about 2 per cent. for atmospheric pressure. Thus the specific electric double refraction of a substance in the gaseous state is a constant quantity. Moreover, this quantity is found to differ little from the specific electric double refraction for the same substance in a liquid state. A table is given of the Kerr constants obtained for 12 gaseous substances. Measures were also undertaken for some of the same substances in a state of dilute solution, and it was found that, though the Kerr constant is proportional to the concentration, yet the value differs from the value for the same concentration in the gaseous state by an amount dependent on the solvent. The author's results appear to him to exclude certain hypotheses relating to the mechanism of double refraction which are based on grouping of the molecules, and rather to lend support to theories concerned with orientation. A. E.

306. *Lehmann's Liquid Crystals.* **C. Mauguin.** (Phys. Zeitschr. 12. pp. 1011–1015; Discussion, p. 1015, Nov. 15, 1911. Paper read before the 83. Naturforscherversamml., Karlsruhe.)—The author has succeeded in preparing homogeneous liquid crystals up to 0·15 mm. in thickness; these show all the optical properties characteristic of solid uniaxial crystals. Their orientation is determined by two films in contact with the parallel glass surfaces, which in turn derive their orientation from the solid from which they were prepared. If these two films are set with optic axes parallel to the surfaces they can be rotated relatively to one another and then give rise to interesting screw-formed structures, the optical properties of which are described. T. M. L.

307. *Anomalous Dispersion in Luminous Hg-vapour.* **P. P. Koch and W. Friedrich.** (Phys. Zeitschr. 12. pp. 1193–1197, December 15, 1911.)—Light from a 110-volt quartz mercury lamp was passed through a lens to render it parallel and was then allowed to fall on the plate (P_1) of a Jamin interferential refractor, the plate being placed at an angle of 45° with the light path and thus dividing it into two beams. The transmitted beam was reflected from a plane mirror, was then passed through the special absorption lamp, and finally reflected from a plane parallel glass plate (P_2) to the spectral apparatus, while the beam reflected from P_1, after reflection from a second mirror, passed through P_2 to the spectral apparatus. With this arrangement anomalous dispersion was obtained. Photographs are given showing the appearance obtained with the green line $\lambda = 5461$. The anomalous dispersion obtained is of the normal type, *i.e.*, the index of refraction of the luminous Hg-vapour is greater on the red side of the line than on the violet side. Both yellow lines gave similar effects, but anomalous dispersion was not observed with certainty for any of the satellites of the principal lines. A. W.

308. *Distribution of Brightness in Nature.* **H. E. Ives and M. Luckiesh.** (Amer. Illum. Engin. Soc., Trans. 6. pp. 687–700; Discussion, pp. 700–702, Oct., 1911.)—The authors point out the great distinctions between artificial illumination and daylight; by studying the latter and determining the conditions which are pleasant and the reverse, information of value in planning artificial lighting may be expected. The authors have therefore carried out a series of photographic tests of brightness in nature, using for the purpose a special plate and filter, making the sensitiveness of the plate identical with that of the eye. They show vertical sectional views of various landscapes, the density of the photograph being at each point proportional to the visual darkness of the object. From the examination of these sections polar curves of brightness can be plotted. The eye will tolerate a greater brightness from above than below the horizontal and dislikes large areas of uniform brightness. Data are given for the brightness of the sky under different conditions. Thus blue sky gave 2·2 c.p. per sq. in.; white cloud, 10·4; dark overcast sky, 1; and a brightly illuminated pavement, 6. The ratio between the brightest and darkest points in an average varied landscape is about 20 : 1. J. S. D.

309. *Blackening and Photometry of Photographic Plates.* **L. Geiger.** (Ann. d. Physik, 37. 1. pp. 68–78, Dec. 29, 1911.)—Bunsen and Roscoe stated that equal amounts of energy, *i.t*, produce equal blackening. Schwarzchild has proved experimentally that this law is only a crude approximation, and he further stated that equal values of $i.t^p$ cause equal blackening. Lines of equal blackening are now termed "equi-opaque." It is shown geometrically that the blackening surface in the log *i*, log *t* plane is represented by a system of rectilinear "equi-opaques." With a given treatment and for monochromatic light a photographic plate is fully characterised by the "blackening surface" in respect to the blackening. The Stark law of blackening for the region of normal lighting is obtained as a result of the analysis of the blackening surface. The best method of determining the three Stark constants is investigated. The method of applying the use of blackening planes in the photometry of photographic plates, in particular those which have been subjected to a slight exposure, is considered. A. E. G.

310. *Helium Tubes as Light Standards.* **P. G. Nutting.** (Washington Acad. Sci., Journ. 1. pp. 221–222, Nov. 19, 1911.)—Capillary tubes of about 2 mm. bore containing helium gas have proved to have useful characteristics as standards of light. The tubes are subjected to a high-tension discharge, the standard current being 25 milliamps.; a consumption of 8·8 watts per c.p. is then obtained. The light is furnished mainly by six prominent spectrum lines. These all increase in intensity uniformly with increasing current, and the connection is approximately linear. Neither voltage nor frequency affect the light appreciably, and the gas density has little effect between the limits of 3–8 mm. pressure. A test of reproducibility of candle-power was made on 40 tubes. The average deviation was 1·15 per cent., the maximum 8 per cent. Further particulars on this point will be given later in the Bulletin of the Bureau of Standards. J. S. D.

311. *Groove-form and Energy Distribution of Diffraction Gratings.* **A. Trowbridge** and **I. B. Crandall.** (Phil. Mag. 22. pp. 534–547, Oct., 1911.)—Describes an extension of the work of Wood and Trowbridge [Abstract No. 282 (1911)] towards the visible spectrum. Several diagrams are given and the results discussed. It appears that the energy is, in general, thrown out principally at the angle at which it would naturally be reflected, and that there is an effect due to the diffraction of the energy by the single elements. These two properties are not at all independent; for there can be no energy reflected from a surface in a direction such that the retardation over the surface gives rise to a destructive diffraction. An echelette grating, in which these two effects are combined, behaves from the standpoint of the distribution of energy in every respect similarly to the ordinary grating; the difference being that, whereas in the grating the energy in the various spectra on either side of the central image falls off in certain ratios, in the echelette

grating the point of reference is the oblique image, and the same ratios should hold for the energy in the spectra symmetrically disposed about the oblique image. The absent orders in the echelette spectra are exactly paralleled by the absent orders with a flat grating, any arbitrary portion of whose element is reflecting: the remainder throwing off no energy. A. W.

312. *Summational and Differential Vibrations in Line Spectra.* **E. E. Mogendorff.** (Konink. Akad. Wetensch. Amsterdam, Proc. 14. pp. 470–481, Dec. 28, 1911.)—The author has found that it is the intensest lines of a spectrum (especially the first doublet of a principal series, which gives a flame its characteristic colour) that give rise to the existence of combinational vibrations. The intensity of the summational and differential vibrations is, however, comparatively slight; uncertainty may prevail with regard to the lines lying in the infra-red; for a number of lines in the visible spectrum the slight intensity appears already from the fact that they have not been seen by earlier observers. The presence of combination lines points to the existence in the vibrating system of some oscillations of so great an amplitude that the law of the simple pendulum, that the force which repels the vibrating particle (system) to its state of equilibrium is proportional to the deviation, does not hold for them. This force now depends also on higher powers of the deviation. If we assume, as Helmholtz did for combination tones, that the force also depends on the square of the amplitude, a new system of combinational vibrations may be expected from two such vibrations. Illustrations are given of this principle from lines in the spectra of Li, K, Rb, Cs, and H. Paschen has recently shown the existence of a number of combinations in the spectra of Th, Cd, Mg, Ca, and Hg. Moreover, the principle of combination appears to point here to summational and differential vibrations of the most intense lines of the already known series, so that we can account for the new lines without making use of a spectral formula. In Paschen's paper [Abstract No. 1486 (1911)] on the series spectra of Zn, Cd, and Hg it is particularly the very intense lines Zn 2138·6, Cd 2288·1, and Hg 1849 which occur in combinations; so they must be considered as first lines of principal series lying in the ultra-violet. This principal series is indicated by 1·5 S — *m* P. [See Abstracts Nos. 1619 (1908) and 285 (1909).] A. W.

313. *Spectrophotography of Chemical Reactions and Effect of High Temperatures on Absorption Spectra of Non-aqueous Solutions.* **H. C. Jones** and **W. W. Strong.** (Amer. Chem. Journ. 47. pp. 27–85, Jan., and pp. 126–179, Feb., 1912.)—The stability of compounds of solvent and solute has been studied by means of absorption lines and bands. In a number of cases mixed solvents show two sets of absorption bands; in such cases the reciprocals of the percentages of the two solvents when the bands are of equal intensity are used as a measure of the "persistency" of the two "solvates." The persistency of the bands is quite different for different salts. In the case of neodymium chloride in water and alcohol the bands are of the same intensity when 8 per cent. of water and 92 per cent. of alcohol are present. In the case of samarium chloride the water bands have a greater persistency and a smaller percentage of water is required. The persistency of the water bands of neodymium nitrate is different from those of the chloride. The water bands of the uranous salts are much less persistent, the water and alcohol spectra being of about the same intensity when there is about 40 per cent. of water and 60 per cent. of alcohol present. The persistency of the bands of the same salt in different solvents is very different. In general, the "water" bands are the most persistent of all the solvent bands at ordinary temperatures. The persistency of solvent bands depends on the concentration of the solution. Keeping the percentage of water and alcohol constant, it is found that the alcohol bands of neodymium chloride and of the uranous salts are relatively more persistent for the greater dilutions, *i.e.*, Beer's law does not hold for solutions containing two solvents. Rise of temperature changes the relative intensity of the solvate bands. Uranous chloride was dissolved in a mixture of water and ethyl alcohol in such proportions as to show the water and alcohol bands of the same intensity at ordinary room temperatures; on heating the solution to about 80° the water bands practically disappeared, leaving only the uranous alcohol bands in the spectrum. T. M. L.

314. *Radiation from Mercury Lamp.* **L. Grebe.** (Ann. d. Physik, 36. 4. pp. 834–840, Dec. 7, 1911.)—By means of a lens an image of a quartz mercury lamp was thrown on the tube of a second lamp which had plane parallel walls. The light from both lamps was then focussed on the slit of a Brace spectrophotometer. The light from the first lamp could be cut off by means of a screen. A third lamp served for comparison. The current and p.d. of the first and third lamps was kept constant, while the energy consumption of the second could be varied at will. The intensity of this latter was first measured, then the intensity of the two together, and finally that of the first alone. Tables and graphs are given showing how the absorption varies with energy consumptions in the second lamp of from 100 to 540 watts. For both the green ($\lambda = 546\ \mu\mu$) and blue ($\lambda = 436\ \mu\mu$) lines the curve showing the relation between E/A and the energy consumption of the second lamp is practically a straight line (E = emission, A = absorption). Hence the increase of intensity of a single line is proportional to the temperature-increase, which is in agreement with Rayleigh's law of radiation for a black body. The law is known to hold for large values of λT, and these experiments now show a qualitative agreement for short wave-lengths, and also, within the limits of error, a certain quantitative agreement. [See Abstracts Nos. 1182 (1907) and 1796 (1908).] A. W.

315. *Variation of Calcium Spectrum with Vapour Density.* **O. J. Lee.** (Astrophys. Journ. 34. pp. 397–403, Dec., 1911.)—In the study of stellar spectra the simultaneous appearance of strong sharp lines of Ca and broad lines of H, He, &c., has not yet had any satisfactory explanation. Radial velocity determinations frequently show a considerable degree of abnormality for the calcium lines. The author has recently made a series of experiments, with Ca volatilised in a rapidly rotating carbon-tube heated in a specially arranged electric arc. It is concluded that the lines λ4227 and λ3968 require for reversal vapour-densities about 1/7 and 3/2 respectively, of that necessary for a reversal of 3934, when the vapour is observed at a temperature of 2500° C. at atmospheric pressure. C. P. B.

316. *Separation of Spectra in Compound Gases.* **G. Stead.** (Phil. Mag. 22. pp. 727–733, Nov., 1911.)—In a previous paper [Abstract No. 1488 (1911)] experiments were described giving evidence that a process somewhat akin to electrolysis can occur in gases at low pressure. The present paper gives an account of further work on the same subject. A discussion of the results is given. When an electric discharge is passed through a gas at low pressures the spectrum of the glow around the kathode differs from that of the light in the neighbourhood of the anode. In compound gases the spectra which

appear at the kathode are due to atoms which, from chemical considerations, must be supposed to carry a positive charge. Similar remarks apply to the anode. It is thought that the principal factors which determine the differences in the spectra at the two electrodes are: (i) The difference in temperature and electric intensity at the two poles. (ii) The electrochemical character of the elements concerned. **A. W.**

317. *Spectra of the Electrodeless Ring Discharge in Certain Gases.* **H. Donaldson.** (Phil. Mag. 22. pp. 720–727, Nov., 1911.)—In an ordinary discharge tube with electrodes, the interpretation of the differences in the spectra of a gas in different parts of the tube is rendered difficult by the separation which takes place between the positive and negative ions. It was thought, therefore, that a study of the spectra of gases in the oscillatory ring discharge, in which a permanent separation between the ions would be unlikely, might afford useful information concerning the dependence of the spectra upon the strength of the ionising field. The gases dealt with were air (with and without oxygen) H, CO_2, CO, O, Ar, HCl, HBr, SO_2, CS_2. The experiments clearly indicate a dependence of the spectrum of a gas on the electric field responsible for ionising the gas. In most cases the results support those previously obtained by Stead [see Abstract No. 1483 (1911)] from observations of the discharge spectra in tubes with metal electrodes. In the ring discharge in oxygen the elementary line spectrum is characteristic of the discharge at the highest electric intensities used, the band spectrum at intermediate intensities, and the compound line spectrum at the lowest intensities. The only possible difference between the results obtained by the two methods is connected with the continuous spectrum, which in the discharge tube appears at the lowest intensities and in the ring discharge at an intensity between those for the compound line and band spectra. The existence of a band spectrum occupying a position intermediate between two line-spectra of the same element is interesting in view of suggestions that have been made to ascribe line spectra to atomic and band spectra to molecular systems. In the ring discharge the Swan spectrum only appears in CO when it is very nearly pure, and then at a high intensity, and the same bulb may show the carbon band spectrum at a low intensity, and the same, mixed with the Swan spectrum, at a higher intensity. In the cases of nitrogen and residual air the ring discharge is peculiar in that it has never shown any clear evidence of the presence of the negative band spectrum, the variation from the positive band spectrum to the line spectrum taking place directly. A bulb containing cyanogen, which was not sufficiently pure to give its own band spectrum, showed a change from the positive to the negative nitrogen band-spectrum with increasing electric intensity, but this was never observed in nitrogen itself. The general results agree with those given by discharge tubes in assigning the positive band spectrum in nitrogen to the weakest ionising fields, and the line spectrum to the strongest, between them being the negative band spectrum. **A. W.**

318. *Spectra of Various Substances in the Oxy-hydrogen and in the Chlorine-hydrogen Flame.* **A. Harnack.** (Zeitschr. wiss. Phot. 10. pp. 281–312, Dec., 1911, and pp. 313–346, Jan., 1912.)—Nine elements were dealt with: Ca, Sr, Ba, Mg, Cu, Mn, Pb, Ni, and Co, and the spectrum of each was examined in both flames, the Cl-H flame giving a temperature of from 2300° to 2400° C. The spectra in the Cl-H flame of seven of these elements were first obtained, and in this way the chlorine spectrum was isolated. In general it was found

that, apart from the chloride bands, no bands existed which were common to the two flames. The Cl-H flame for all the elements investigated is characterised by a relative barrenness of lines. Distinct nitrate bands were in no case observed. For Ca and Sr besides the metal and oxide bands additional distinct oxidation bands must be recognised. Calcium shows several new chloride bands (or lines ?) ; and, further, distinct bands which are characteristic for the combinations metal-Cl-flame and chloride-O-flame. In the oxygen flame Sr shows a group of new bands in the ultra-violet about $\lambda = 3300$; it was also decided that a nitrate spectrum is non-existent. Ba in the oxygen flame gives a great number of new ultra-violet bands to $\lambda = 2880$, and in the Cl-flame a new group of ultra-violet chloride bands which correspond with those obtained by King [see Abstract No. 1565 (1905)] in the electric oven. Cu gives in the oxygen flame new bands between $\lambda = 4000$ and $\lambda = 3400$, and in the Cl-flame a continuation of the known chloride bands into the ultra-violet. Mn did not show the known band spectrum. Pb, Ni, and Co show considerable differences in the spectra of the two flames. Photographic reproductions of the various spectra are given. A. W.

319. *Magnetic Spectra of the β-Rays from Radium.* **O. v. Baeyer, O. Hahn, and L. Meitner.** (Phys. Zeitschr. 12. pp. 1099–1101, Dec. 1, 1911.)—A continuation of the authors' work previously dealt with [Abstracts Nos. 1710 (1910) and 1187 (1911)]. It is shown that both the active deposit of Ra and Ra itself give a magnetic line spectrum. The velocity of the β-rays was determined from their magnetic deflection. A. W.

320. *Characteristic Röntgen Radiations.* **R. Whiddington.** (Nature, 88. p. 143, Nov. 30, 1911.)—From Barkla's experiments [Abstract No. 1498 (1911)] it appears that some elements of high atomic weight give "two lines in the fluorescent spectrum." Optical analogy suggests that there may be some simple relation connecting these spectral lines. The author has shown elsewhere that the radiation characteristic of an element of atomic weight w is the same (when tested by penetrating power) as the most penetrating of the Röntgen rays emitted from an antikathode bombarded by kathode rays of velocity equal to kw, where $k = 10^8$. Barkla says that Bi gives out (in series L) a radiation of very nearly the same penetrating power as that from Se in series K. From this it follows that the equivalent velocity for Bi is the same as for Se, *i.e.*, $7{\cdot}92 \times 10^9$. So that Bi behaves as though it were an element of atomic weight 79. The actual atomic weight of Bi is 208, and it behaves as if its atomic weight were $w' = \frac{1}{2}(w - 50) = 79$. The expression $w' = \frac{1}{2}(w - 50)$ is shown to hold fairly well over the greater part of the range of elements studied by Barkla, and it is suggested that a general formula of this type may prove useful in indicating where to look for new lines in future investigations. A. E. G.

321. *Influence of Shape of Ionisation Chamber on α-Ray Saturation Curve.* **E. Regener.** (Deutsch. Phys. Gesell., Verh. 13. 23. pp. 1065–1078, Dec. 15, 1911. Le Radium, 8. pp. 461–464, Dec., 1911.)—It is well known that it is difficult to obtain saturation with α-rays. Moulin [Abstract No. 1485 (1909)] has shown this to be due to the great density of ions along the trajectories of the α-particles, these ions recombining before the electric field has time to drag them apart. The author has investigated the saturation curves in air due to the α-particles from polonium with different-shaped ionisation

chambers, spherical, rectangular, &c. The results show that saturation is easiest obtained for an ionisation chamber consisting of two parallel plates; the nearer together the plates the smaller the voltage required for saturation. E. M.

322. *Radiation from Boron Nitride.* **A. Remelé.** (Phys. Zeitschr. **12.** pp. 969–972, Nov. 15, 1911. Paper read before the 83. Naturforscherversamml., Karlsruhe.)—The author describes experiments showing that boron nitride (prepared by Wöhler's method) gives a radiation which affects a photographic plate through thin layers of paper, &c. The radiation appears to consist of negatively-charged particles which are capable of producing ionisation phenomena and are intermediate in penetrating power between kathode and β-rays. The radiation was found not to be an atomic property of boron since it was not exhibited by other boron compounds or boron minerals. E. M.

323. *Radio-active Properties of High-temperature Flames.* **H. Carter.** (Phil. Mag. **22.** pp. 805–816, Nov., 1911.)—There is at the present time no well-authenticated case where radio-activity is called into existence by any artificial process. All the known phenomena in this branch of science are due to the spontaneous atomic disintegration observed in naturally active substances. If such an atomic disintegration can, under any circumstances, be set going artificially, it seems likely that this would occur in cases where large quantities of energy are being set free in a small volume. Such cases are those of the electric arc, the spark, and the oxyhydrogen and oxyacetylene blow-pipe flames. It is practically impossible to test with any great refinement for the emission of α-radiation in any of these processes, on account of the enormous ionisation of non-radioactive origin already present. The authors have therefore made searching tests for the emission of β-rays from these sources. A gold-leaf electroscope was used, one side consisting of thin foil through which β-rays could pass. Special water-cooling arrangements were necessary to prevent fluctuations of the gold-leaf due to temperature variations. The leak of the electroscope was compared with and without the source, but in no case was any radiation detected with certainty. E. M.

324. *Period of Transformation of Radium Emanation.* **E. Rutherford.** (Akad. Wiss. Wien, Ber. **120.** 2a. pp. 303–312, March, 1911.)—By a compensation method, in which the ionisations produced by the γ-rays from two quantities of RaEm are balanced, the author finds that the decay is independent of concentration and is the same at the temperature of liquid air as at ordinary temperature. The paper also deals with a determination of the period of the emanation. A strong source of RaEm is compared with a Ra standard by a γ-ray electroscope and afterwards allowed to decay for about 100 days. The tube containing the Em is then opened and the Em transferred to a standardised emanation electroscope, where it is measured. The period is deduced from the observations, and owing to the large interval of time involved an error of 10 per cent. in either determination only leads to an error of about ¼ per cent. in the value of the period. The mean value found is $8{\cdot}84_6$ days [$\lambda = 0{\cdot}1802\ (\text{day})^{-1}$], which is in good agreement with the value 8·85 days found by Mme. Curie [Abstract No. 566 (1910)]. E. M.

325. *β-Rays of Radium Products.* **J. Danysz.** (Comptes Rendus, **153.** pp. 1066–1068, Nov. 27, 1911. Le Radium, **9.** pp. 1–5, Jan. 1912.)—The author has continued his experiments on the magnetic spectrum of the β-rays given out from RaEm, in equilibrium as far as RaC, enclosed in a very thin-walled glass tube ("α-ray tube") [Abstract No. 1849 (1911)]. The results show that there are at least 28 sets of β-rays of distinctly differing velocities varying from 0·615 to 0·996 times the velocity of light. The velocities were calculated from the Lorentz formula $RH = mc/e \times \beta/\sqrt{(1-\beta^2)}$, where m and e are the mass and charge of an electron and $e/m = 1{\cdot}772 \times 10^7$; C is the velocity of light $3{\cdot}001 \times 10^{10}$, β the speed of the β-ray expressed in terms of the velocity of light, H the strength of the magnetic field, and R the radius of curvature of the particular band of β-rays. There was also evidence that a few of the β-rays have velocities as high as 0·998 times the velocity of light. E. M.

326. *Radium Active Deposit in the Atmosphere.* **K. W. F. Kohlrausch.** (Akad. Wiss. Wien, Ber. 119. 2a. pp. 1577–1604, Nov., 1910.)—Air was drawn by means of an aspirator through an earthed cylinder along the axis of which a highly-charged negative electrode was fixed. The current of air was allowed to pass in all cases for exactly 5 min., and the saturation current measured immediately after stopping the stream. Under these conditions the ionisation is due to RaA and RaC deposited on the electrode. It was found that the saturation current thus measured was smaller at midday than in the morning, and was greater with greater humidity of the atmosphere. A max. effect was found with a falling barometer and a minimum with rise in pressure. The change in the distribution of the mobilities of the ions with changes in the meteorological conditions was also investigated. E. M.

327. *Period of Polonium.* **E. Regener.** (Deutsch. Phys. Gesell., Verh. 13. 22. pp. 1027–1033, Nov. 30, 1911. Le Radium, 8. pp. 458–461, Dec., 1911.) —The value found in a series of measurements was 136 days, corresponding to $\lambda = 0{\cdot}005096$ with a probable error of ¼ per cent. The author shows that defect of saturation in ionisation measurements leads to a value of the period which may, under certain circumstances, be considerably too high. E. M.

328. *Optical Properties of Fused Metals.* **J. W. Nicholson.** (Phil. Mag. 22. pp. 266–268, Aug., 1911.)

329. *Optics of Metallic Films.* **K. Försterling.** (Gesell. Wiss. Göttingen, Nachr., Math.-Phys. Klasse, 4. pp. 449–454, 1911.)—Derives formulæ for the calculation of the optical constants of a metallic film of any thickness from the states of polarisation of the reflected and transmitted light. [See Abstract No. 605 (1911).] E. H. B.

330. *Doppler Principle.* **S. Pokrowsky.** (Phys. Zeitschr. 12. pp. 1115–1118, Dec. 1, 1911.)—A discussion of Doppler's principle and W. A. Michelson's theory. [See Abstract No. 1263 (1901).] E. H. B.

331. *Principle of Virtual Displacements in Radiation.* **S. Pokrowsky.** (Phys. Zeitschr. 12. pp. 1118–1125, Dec. 1, 1911.)—A mathematical paper which applies the principle of virtual displacements to a system immersed in radiation. E. H. B.

332. *Intensity Ratio of Series Lines of Hydrogen in Canal-ray Spectrum.* **J. Stark.** (Ann. d. Physik, 36. 4. pp. 861–865, Dec. 7, 1911.)—In this paper the author criticises the results obtained by Lunkenheimer [Abstract No. 49 (1912)], and also the conclusions deduced from the observations. The results of experiments by Paschen, Royds, and Steubing and Stark [Abstract No. 1085 (1909)] are opposed to the conclusions of Lunkenheimer. A. W.

HEAT.

333. *Temperature Variation of Thermal Expansion Coefficients.* **C. L. Lindemann.** (Phys. Zeitschr. 12. pp. 1197–1199, Dec. 15, 1911.)—Grüneisen [see Abstract No. 1422 (1911)] has recently shown thermodynamically that for monatomic substances, the quotient of the coefficient of thermal expansion by the specific heat must be independent of the temperature if the specific heat is given by an equation of the form $C_p = F(T/v)^a$, and if dv/dp is independent of the temperature. Nernst and Lindemann [Abstract No. 1182 (1911)] have given a formula which allows the specific heat to be calculated. This function satisfies the above conditions, apart from correction terms, so it is interesting to test Grüneisen's relation at very low temperatures. This was done for Al, Cu, Zn, Ag, and Pb, and the results establish the truth of the relation for these metals. The investigation of several non-metals is unfinished.

A. W.

334. *Melting-points of Tantalum and Tungsten.* **W. E. Forsythe.** (Astrophys. Journ. 34. pp. 353–370, Dec., 1911.)—The metals are used as filaments or as hollow wedges for black-body measurements with the aid of a vacuum furnace, resembling those of Arsem and of King (Mt. Wilson Observatory), and a Holborn-Kurlbaum pyrometer designed by Mendenhall. A melting wedge of tantalum gave the melting-point 2798° C.; two methods yielded for tungsten 2974° C. and 3080° C. These values differ somewhat from those of Waidner and Burgess, v. Pirani, and v. Wartenberg; the deviations would partly be explained by the different assumptions for the melting-point of Pt, which Forsythe fixes at 1755° C. in agreement with Day and Sosman.

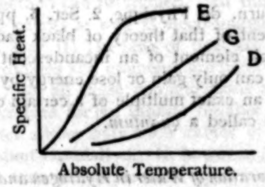
H. B.

335. *Thermal Conductivity at High Temperatures.* **M. F. Angell.** (Phys. Rev. 33. pp. 421–432, Nov., 1911.)—Describes previous work on thermal conductivity of metals, and points out some discrepancies. The method used by Angell is a new one suggested by C. E. Mendenhall, and consists of electrically heating a rod of the metal to be examined and measuring the temperature at the centre and circumference of the rod. Equations based on the mathematical theory of heat-flow and involving assumptions of the variation of electrical resistance with varying temperature over the cross-section are deduced. From these equations and the measurement of energy-flow in the steady state, the conductivity is obtained. The rod is 1·2 cm. external diam., and about 6 in. long. Over a central zone of 1·5 cm., the internal diam. is 0·168 cm.; on either side of this zone the bore is larger, so as to increase the electrical resistance of the end portions. The energy-flow is determined by measuring the current flowing along the bar and also the p.d. between two points on the central zone distant axially about 1·0 cm. The distance apart of these points is measured very accurately, as from it the resistance is deduced. The temperatures at the inner and outer surfaces are determined by Pt and Pt-Rh couples. The thermal conductivities of Ni between 300° and 1200° C. and of Al between 100° and 600° C. are examined. There appears no constant ratio between electrical and thermal conductivity for these metals at high temperature. Nickel is found to possess a third allotropic state at about 700° C., and a change in the form of the thermal and electrical conductivity curves at this point. The magnetic critical temperature is shifted through a range of 180 deg. C. by heat treatment; annealing from high temperatures giving a low value and sudden cooling producing values as high as 420° C. The electrical resistance of Ni between 0° and 1200° C. and of Al between 0° and 600° C. are given. In the case of Ni the change in form of the curve which accompanies a change in the magnetic critical temperature due to heat treatment is determined. The author finds that the temperature-resistance curve can be approximated by a parabola only when the critical temperature is in the neighbourhood of 370° C. H. S. R.

336. *Thermal Conductivity of Powdered Bodies.* **M. Smoluchowski.** (Acad. Sci. Cracovie, Bull. 8a. pp. 548–557, Oct., 1911.)—To his previous measurements [see Abstract No. 1788 (1910)] the author now adds measurements of the thermal conductivity of powdered substances *in vacuo*, so that the interstices between the grains are freed from gas. The conductivity, in this case, results from the superposition of two processes—propagation of heat across the grains, and radiation between two neighbouring grains. This residual conductivity is only some hundredths of the normal value under atmospheric pressure. The contact conductivity has a value of $1{\cdot}24 \times 10^{-6}$, while the radiation conductivity varies between $0{\cdot}05 \times 10^{-6}$ and $0{\cdot}26 \times 10^{-6}$. The author has also calculated the value of the contact conductivity by means of the formulæ of Hertz, and finds a value of the order 1×10^{-3}, whereas the experimental value is a thousand times less, 1×10^{-6}. This discrepancy is explained as due to a layer of oxide on the metal. The author has also compared the heat conductance with the electrical, to see whether there is any heat effect comparable with the coherer effect in electricity. A negative result was obtained. A. F.

337. *Thermal Conductivity and Convection in Gases at very High Temperatures.* **I. Langmuir.** (Amer. Electrochem. Soc., Trans. 20. pp. 225–237; Discussion and Communication, pp. 237–242, 1911.)—A brief account of noteworthy researches commenced years ago under Nernst, and continued in the General Electric Co.'s laboratories at Schenectady. When a very slow air-current is passed over a Nernst glower, or a glower heated in air in a vessel of 1 litre capacity, the yield of NO is always very much smaller than would correspond to the temperature; but the discrepancy rapidly vanishes as really high temperatures are reached. This suggests a rapid rise in the conductivity of the air with temperature, probably due to a dissociation of the gas molecules into atoms under heat absorption, and a recombination of the atoms under heat liberation at some distance from the glower. This assumption is confirmed by experiments made by the author in conjunction with A. H. Barnes with tungsten filaments (from 0·028 mm. to 0·28 mm. in diam.), stretched, vertically as a rule, but also horizontally, axially or bent in wide tubes (4 cm. diam.) of glass or brass. The width of the cylinder made little difference in the energy required to heat the wire, and the position of the wire in the cylinder had little effect at high temperature (strong influence at low temperature). The gas near the wire did not carry any appreciable electric current at 2900° K. Up to 1800° K. the energy loss through the gas was about proportional to the temperature; at 3400° K. it was proportional to the tenth power of the temperature. Tungsten radiates 0·51 times as much light as a black body. The fine tungsten wires carried in the hydrogen atmosphere at atmospheric pressure currents of extraordinary intensity, about 30 times as great as when heated in a good vacuum. Photometric observations suggest a melting-point for tungsten of at least 3450° K. H. B.

338. *Low-temperature Work.* **J. Dewar.** (Engineering, 93. pp. 122–123, Jan. 26, 1912. Discourse delivered at the Royal Institution.)—As the absolute zero is approached, the scale of temperature to be used and the methods to be adopted in measuring it, become more and more serious questions, temperatures within 2° of the absolute zero having been attained. Within certain limits resistance-thermometers or thermo-couples are available, but for extreme conditions the only method that we dare use is based, on the changes with temperature, in the pressure of a gas far removed from its point of liquefaction, and under a small initial pressure. As very small differences of pressure have to be measured, the limits that could be reached with particular gases require consideration. The practical limits of gas thermometers are as below.



Gas.	Initial Pressure at 0° C. in mm. of Hg.	Limit to which Applicable in Degrees Absolute.
CO_2	(0·5) × 273	171·4
O	(0·5) × 273	69·2
H	(0·5) × 273	11·72
H	(0·1) × 273	10·40
Helium........................	(33) × 273	2·95
Helium........................	(0·5) × 273	1·90
Helium........................	(0·1) × 273	1·71

The specific heats of bodies at low temperatures have been studied by Nernst and compared with Einstein's theory. The comparison is shown in the Fig., in which E shows Einstein's curve, G and D the experimental curves for graphite and diamond respectively. The latter has nearly no specific heat. Nernst has shown that before the absolute zero is reached the specific heat has vanished. This raises difficulties from the theoretical standpoint, and the explanation must be sought in the world of electrons. E. H. B.

339. *Ether Calorimeter.* **F. Neeson.** (Deutsch. Phys. Gesell., Verh. 13. 22. pp. 1023–1026, Nov. 30, 1911.)—Duane [Abstract No. 1073 (1909)] has used, for the determination of the heat given out by radium, a method depending on the large increase in vapour pressure of ether with

small elevations of temperature. The present paper deals with experiments on the most sensitive arrangement of such an apparatus. It is shown that it is not necessary that the tube containing the source of heat should dip into the liquid ether, but that greater sensitiveness is obtained, and equilibrium produced quicker, if the tube is surrounded by the vapour only. E. M.

340. *Isothermal Changes of Air at Various Pressures.* **P. v. Schrott.** (Akad. Wiss. Wien, Ber. 120. 2a. pp. 165–174, Feb., 1911.)—Deals with the isothermal changes of air driven through a small aperture at the end of a cylinder in which a piston is advancing at uniform speed. A formula is obtained and different apertures are dealt with. E. H. B.

341. *Radiation Quanta.* **H. Poincaré.** (Comptes Rendus, 153. pp. 1103–1108, Dec. 4, 1911. Journ. de Physique, 2. Ser. 5. pp. 5–34, Jan., 1912.)—A mathematical treatment of that theory of black radiation by M. Planck, according to which each element of an incandescent solid is likened to a Hertzian resonator, but can only gain or lose energy by a sudden change and of an amount which is an exact multiple of a certain quantity characteristic of the wave-length and called a *quantum.* E. H. B.

342. *Velocity of Evaporation of Water in Hydrogen and in Air.* **H. Mache.** (Akad. Wiss. Wien, Ber. 119. 2a. pp. 1399–1428, Oct., 1910.)—According to Stefan's law with respect to the velocity of evaporation of liquids contained in tubes into a vapour-free atmosphere, the quantity of vapour passing through unit section of the tube in unit time is given by the formula $\mu = \Delta/h\ [\log b/(b - p_0)]$, where Δ is the diffusion coefficient of the vapour and of the gas above the surface of the liquid, h is the depth of the deepest point of the meniscus below the top of the tube, b is the air pressure, and p_0 the partial pressure of the vapour immediately above the surface of the liquid. Stefan puts p_0 equal to π, the saturation pressure of the vapour at the given temperature, and uses the above formula to calculate Δ. The author disputes this assumption and puts $\mu = K(\pi - p_0)$, where K, the proportionality factor, can be designated as the evaporation coefficient. By equating this formula with the one given above, the author finally deduces that the time (t) necessary for the level of the liquid in the tube to fall 1 mm. is given by the equation $t = A + Bh$, where A and B are constants. This equation is applied to Winkelmann's results and found to give a very good agreement between theory and experiment. Fresh experiments with air and hydrogen as the gases, and at different temperatures, between 26·97° and 92·40° C., show that the straight lines represented by the above equation cut the axis at the same point, that is, have the same value for A. From these results the author is able to calculate the diffusion coefficient of the water-vapour, and finds a very good agreement between theory and experiment, both in hydrogen and in air. Tables are also given of the values of $\pi - p_0$ for different values of h at different temperatures; thus at 92·4° the values are 48·6 and 29·2 mm. Hg for $h = 30$ mm. in hydrogen and air respectively. On the assumption that the quantity of vapour given off by a liquid is regulated not only by diffusion in the gas above the liquid, but also by a diffusion current in the interior of the liquid, the author gives a theoretical deduction of the relation $\mu = K(\pi - p_0)$. The evaporation coefficient, K, is greater for low than for high temperatures. T. S. P.

343. *Partition of Energy between Matter and Radiation.* **S. B. McLaren.** (Phil. Mag. 21. pp. 15–26, Jan., 1911.)—Jeans considers radiation in a finite enclosure with reflecting walls, and is enabled to draw conclusions as to energy partition only by the assumption that there is one dynamical system of which matter and ether are parts, that Maxwell's statistical method can be applied to it, and that in any complete formula for the energy his expression for the energy will form a part. The author derives such a formula on the assumption that matter is atomic, his electron being an invariable distribution of charge free to move only as a whole. It then appears that the whole electromagnetic energy must be regarded as belonging to the radiation, excepting only a term which depends on the positions of the electrons at any instant, and would represent the electrostatic energy if they were at rest. In this division nothing is left for kinetic energy of the electrons, the system of equations cannot be brought to Hamilton's form, and it does not seem that Maxwell's statistical method can be applied. All this is, however, possible if there be true material energy as well as electromagnetic. The postulates of the statistical method are: (1) The laws of heat are dynamical; (2) any sets of values of the co-ordinates and momenta are possible if consistent with the constancy of energy; (3) all these configurations are of equal probability. Now (2) is not always true for an infinite number of co-ordinates, *e.g.*, the vortex theory of matter allows only such values of the variables as satisfy the condition of constant circulation. If, however, (2) were abandoned, this would not preclude a state of temperature equibrium, but would rather lead to the inference that heat depends on properties of matter other than the abstractly dynamical, as indeed appears from the laws of radiation, which, as Jeans has shown, involve an absolute constant of the dimensions of a length, which cannot enter into the purely dynamical scheme. The author observes that it may be objected the radiation here taken as such is not real radiation, since the field immediately surrounding an electron should be reckoned as part of the electron's energy. The attempt, however, thus to distinguish radiation from what is not radiation leads to a set of equations which do not belong to a dynamical system at all. G. W. DE T.

344. *Statistical Theory of Radiation.* **L. Natanson.** (Acad. Sci. Cracovie, Bull. 3a. pp. 134–148, March, 1911. Phys. Zeitschr. 12. pp. 659–666, Aug. 15, 1911.)

345. *The Quanta-Emission Hypothesis.* **M. Planck.** (Preuss. Akad. Wiss. Berlin, Ber. 35. pp. 723–731, 1911.)

346. *Inconsistency of my Heat Theorem and van der Waals' Equation at very Low Temperatures.* **W. Nernst.** (Konink. Akad. Wetensch. Amsterdam, Proc. 14. pp. 201–204, Aug. 28, 1911.)

347. *Gas Theory on Relativity Principle.* **W. H. Westphal.** (Deutsch. Phys. Gesell., Verh. 13. 21. pp. 974–977, Nov. 15, 1911.)—Corrects some errors in a previous article on this subject [see Abstract No. 1428 (1911)]. E. H. B.

SOUND.

348. *Anomalous Propagation of Sound.* **S. Fujiwhara.** (Mathematico-Physical Soc., Tōkyō, Proc. 6. 1. pp. 132–142, Oct., 1911.)—The sound phenomena which attended the remarkable dynamite explosion of the Jungfrau Railway reported by A. de Quervain (1908) and that at Förde in Westphalia, reported by G. von der Borne, have aroused the attention of several physicists. Recently Borne (1910) has introduced the new ideas of the isothermal layer and hydrogen atmosphere into the problem as a possible explanation. The characteristic features to be elucidated are the existences of normal, silent, and abnormal ranges of audibility surrounding the place of explosion. The present author has particularly studied a number of eruptions in Dec., 1910, of Mount Asama, an active volcano in Central Japan. He also deals with an explosion on a ship in Kōbe Harbour in April, 1910. He thus finds that the region of audibility lies in a direction from the source coinciding with the wind direction in the middle strata of the atmosphere. A mathematical theory is then developed in which the air's viscosity is neglected, the atmosphere supposed to be in connective-equilibrium, with wind blowing horizontally in one definite direction, its velocity changing very slowly with height. It is thus shown that the observed phenomena can be accounted for without any recourse to the isothermal layer or hydrogen atmosphere; for the rays may ascend and thus pass over a region of silence, afterwards returning to the earth's surface at a more distant place. E. H. B.

349. *Kundt's Dust Figures.* **W. König.** (Phys. Zeitschr. 12. pp. 991–994, Nov. 15, 1911. Paper read before the 83. Naturforscherversamml., Karlsruhe.)—The author reviews his theory of the striæ in Kundt's dust figures and the more recent work by S. R. Cook [see Abstracts Nos. 1865 (1902) and 2447 (1904)], by W. Zernov [Abstract No. 1128 (1908)] by J. Robinson, by S. Marsh and W. H. Nottage, and by Schellbach and Boehm. He then describes experiments with dust on a disc in the centre of which an electric spark passes, the striæ being observed with and without a similar disc placed over the first. In free air the striæ distances were taken at radii of 1 and 2, when by the theory of spherical radiation applied to this case the ratio of the distances should be $(1/2)^{2/3} = 0{\cdot}630$. With the covering disc in place about 2 mm. above the other, the radiation is cylindrical and the ratio of the striæ distances should be $(1/2)^{1/3} = 0{\cdot}794$. The means of the experimental ratios were 0·64 and 0·81 respectively for the above cases, thus showing a satisfactory agreement with theory. Other points are discussed which are not yet cleared up. E. H. B.

350. *Sound Records from Flames.* **J. G. Brown.** (Phys. Rev. 33. pp. 442–446, Nov., 1911.)—Details a method of obtaining photographic records of a flame made to vibrate to given sounds by a manometric capsule. The photographs are obtained by means of a coupled stroboscope and piston, due to G. S. Moler. Also a narrow slit was placed before the flame and a revolving mirror used with axis parallel to the slit. In this way very good photographs were obtained (reproduced in the paper) for simple and compound vibratious. [See Abstracts Nos. 65 (1899) and 1091 (1901).]

E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

351. *Poynting's Theorem and the Equations of Electromagnetic Action.* **W. S. Franklin.** (Frank. Inst., Journ. 173. pp. 49–54, Jan., 1912.)—The author simplifies the usual expression of Poynting's theorem and the usual equations of electromagnetic wave-motion to well-known expressions involving voltage and current. Instead of giving the algebraic transformations themselves, a general statement of their nature is given. He shows that Poynting's theorem can be readily deduced in the case of transmission lines from the following fundamental energy theorem: "The rate at which energy streams past a point on a transmission line is equal to EI, where E is the voltage across the line at the point and I is the line current at the point." Assuming this, he proves at once for the case of cylindrical lines, and lines formed of broad metal strip, that the energy stream in ergs per second per square centimetre is $fH/4\pi$, where f is the electric field intensity and H the magnetic field intensity. He then deduces the equation of electromagnetic action from the generalised equations of power transmission along lines. A. R.

352. *Checking of an Electron in a Rarefied Gas.* **R. Seeliger.** (Deutsch. Phys. Gesell., Verh. 13. 23. pp. 1094–1100, Dec. 15, 1911.)—A theory of the resistance experienced by an electron is here developed, which gives for a pressure of 0·01 mm. of mercury a force of the order of 10^{-13} dyne.

E. H. B.

353. *Quantum Hypothesis and Ionisation.* **J. Franck** and **G. Hertz.** (Deutsch. Phys. Gesell., Verh. 13. 21. pp. 967–971, Nov. 15, 1911.)—A theoretical relation is here sought between the quantum hypothesis and the ionisation potential, from which the following conclusion is drawn. If, from Lindemann's equation for the selective photoelectric effect, we calculate the electron frequency for gases, we then obtain wave-lengths of the order indicated by Lenard. This frequency, multiplied by Planck's working element, gives an energy in accord with the minimum to be possessed by an electron in order to produce ionisation. E. H. B.

354. *Charges on Nuclei.* **K. Przibram.** (Akad. Wiss. Wien, Ber. 119 2a. pp. 1719–1758, Dec., 1910, and 120. 2a. pp. 49–76, Jan., 1911.)—These two papers form a continuation of the work of determining the electronic charge by treatment of nuclei. New measurements on phosphorus nuclei are here dwelt with, also sulphur vapour and camphor smoke. Many pages are occupied with the observations taken in this elaborate work, and many curves are plotted to represent the probabilities of the various values of the elementary charge, but no final numerical value is given. [See Abstracts Nos. 686 (1911) and 57 (1912).] E. H. B.

355. *The Electric Charge on Rain.* **J. A. McClelland** and **J. J. Nolan.** (Roy. Irish Acad., Proc. 29a. 5. pp. 81–91, Feb., 1912.)—The paper describes some experiments which have been carried out by the authors at University

College, Dublin, to determine the sign and quantity of the electric charge brought to the earth on rain. After reference to the results obtained by previous workers in this field, and more particularly to those of Simpson [Abstract No. 848 (1910)], a description is given of the apparatus employed at Dublin, and the various possible sources of error are discussed. The series of observations covered the period March 8 to June 22, 1911, during which time a volume of 5795 c.cm. was subjected to measurement, this being equivalent to a fall of 1·2 cm. only. It was found that 88·2 per cent. of this volume was positively charged, and 11·8 negatively, while of the total charge brought down 98·5 per cent. was positive in sign. The charge carried by rain which consisted of very minute drops was always negative, and that on rain of large drops nearly always positive. The authors state that they hope to discuss the results more fully when more data are available. J. S. Di.

356. *The Second Postulate of Relativity and the Electromagnetic Emission Theory of Light.* **O. M. Stewart.** (Phys. Rev. 32. pp. 418–428, April, 1911.)

357. *Derivation from Relativity Principle of the Fifth Fundamental Equation of the Maxwell-Lorentz Theory.* **R. C. Tolman.** (Phil. Mag. 21. pp. 296–301, March, 1911.)

358. *Longitudinal and Transverse Mass of an Electron.* **W. F. G. Swann.** (Phil. Mag. 21. pp. 733–736, June; *corrigenda*, 22. pp. 223–224, July, 1911.)

359. *Number of Electrons concerned in Metallic Conduction.* **J. W. Nicholson.** (Phil. Mag. 22. pp. 245–266, Aug., 1911.)

360. *Conservation of Energy in Moving Systems.* II. **A. Szarvassi.** (Akad. Wiss. Wien, Ber. 120. 2a. pp. 337–382, March, 1911.)—Deals with the conservation of energy and the theory of electromagnetic phenomena in moving bodies. [See Abstract No. 151 (1911).] E. H. B.

361. *Electrons and Least Action.* **A. Wassmuth.** (Akad. Wiss. Wien, Ber. 120. 2a. pp. 161–164, Feb., 1911. Deutsch. Phys. Gesell., Verh. 14. 2. p. 76, Jan. 30, 1912.)—Treats the equations of motion of electrons by the principle of least action. E. H. B

362. *Lorentz-Transformation.* **A. Wassmuth.** (Akad. Wiss. Wien Ber. 120. 2a. pp. 543–550, April, 1911. Deutsch. Phys. Gesell., Verh. 14. 2. pp. 77–78, Jan. 30, 1912.)—Deals with the invariance with respect to the H. A. Lorentz transformation of an expression containing the kinetic potential. E. H. B.

363. *Resistance to Particles moving in Radiation-field Space.* **F. Hasenöhrl.** (Akad. Wiss. Wien, Ber. 119. 2a. pp. 1327–1349, July, 1910.)—A highly analytical treatment. [See Abstract No. 274 (1902).] E. H. B.

364. *Electrical State of the Upper Atmosphere.* **A. J. Makower, W. Makower, W. M. Gregory, and H. Robinson.** (Roy. Meteorolog. Soc., Journ. 37. pp. 341–349, Oct., 1911. Electrician, 67. pp. 742–743, Aug. 18, 1911. Abstract.)—A continuation of the work dealt with in Abstract No. 125 (1910.)

DISCHARGE AND OSCILLATIONS.

365. *Absolute Determination of the Minimum Ionising Energy of an Electron.* **E. S. Bishop.** (Phys. Rev. 33. pp. 325–358, Nov., 1911. Phys. Zeitschr. 12. pp. 1148–1157, Dec. 8, 1911.)—The theory of ionisation by collision has been worked out by Townsend and verified by various observers for different gases at low pressure. In the present experiments theory has been shown to hold for wide ranges of pressure; hydrogen, 1 to 40 cm.; air and CO_2, 1 to 10 cm.—the field strengths being such that only the negative ions were operative in producing ions by collision. The conductivity was started by a controlled source of ultra-violet light falling on an Al electrode. From the results the author calculates the mean values of the potential drop necessary for an electron to produce ions by collision to be 9·66, 6·21, and 10·21 volts corresponding to energies 1·58, 1·01, and $1{\cdot}67 \times 10^{-11}$ erg for hydrogen, CO_2, and air respectively. Equations are also worked out connecting the field strength with the magnitude of the ionisation produced at any pressure, the relations being also extended to mixtures of gases. E. M.

366. *Positive Ionisation from Hot Salts.* **O. W. Richardson.** (Phil. Mag. 22. pp. 689–708, Nov., 1911.)—The author has shown that the positive ions emitted by salts of the alkali metals are atoms of the basic metal carrying a single electronic charge [see Abstract No. 258 (1911)]. He has also pointed out that it would be of interest to ascertain whether the salts of polyvalent elements will emit ions carrying multiple electronic charges. The first part of the present paper deals with this matter, and from the experiments the existence of zinc ions carrying a single charge is demonstrated; the existence of ions of Ca carrying a single charge and those of Zn carrying a double charge appear probable, while ions of Mg carrying a single charge seem possible. The main part of the paper, however, deals with ionisation from salts in a gaseous atmosphere. The experiments are first of all carried out by the strip method as used by Garrett with aluminium phosphate, and by Horton with sodium phosphate. Later a Pt tube is employed. This is closed at one end and about 1 gm. of the salt is placed in the bottom. The closed end is tapered somewhat. The tube is heated in an Heraeus Pt-resistance furnace, being placed in a mild steel tube for this purpose. The central electrode is a brass tube closed and tapered at the lower end. It is found that the effects obtained by this new method are somewhat different from those obtained by the strip method. The results of the experiments are on the whole extremely complex, but it is claimed that they give direct evidence in favour of the view that the positive ions emitted by heated salts are metallic atoms, not necessarily those of the salt which appears to be under examination, but they may be atoms of some other metals whose salts are present as an impurity. With respect to the relative efficiency of the different salts in emitting positive ions, it seems that a good emitter requires a combination of volatility in the possible compounds formed, together with high electro-positiveness of the metallic constituent. In the series of the alkali metals the most electro-positive are the most efficient emitters, and the same is true of the alkaline earth group. The zinc haloids are very efficient, and they combine the qualities postulated. A large number of facts can be reconciled by the view that the ionisation, in certain cases at least, is not emitted directly from the heated salt, but by the action on the Pt of vapours which the salt evolves. In the first place this would explain the very small ionisation at very low pressure which is observed by the strip method. The vapours diffuse away from the strip before they have time to get ionised. By increasing the gas pressure the vapour is prevented from diffusing away from the strip, and so the ionisation increases. In the tube method the vapours are unable to diffuse away from the hot Pt, and so there is little change of emission with changing pressure at low pressures. It is very difficult to account for the great variation with pressure when the strip method is used, except by referring it to chemical changes: but practically nothing is known about the mechanism of chemical reactions at high temperatures. It is suggested that the reaction may be a catalytic one of the type $Ba + Pt = Ba_+ + E + Pt$, where E stands for a negative electron which goes over to the Pt and carries the current, the metal Ba being liberated by the ordinary chemical actions which do not involve the transference of electric charge. In fact, ions may play a very fundamental part in chemical actions at high temperatures, just as they do in solutions at ordinary temperatures. On the whole, there is no reason for supposing that there is any essential difference between the mechanism of the large positive emission from freshly-heated metals and that observed with salts. They both have the same general characteristics, namely, (1) An initial exponential decay with time followed by a slowing off; (2) occasionally the variation with time is more complicated, an intermediate rise to a maximum being observed; (3) the decay with time is quickest when the body is positively charged, and is retarded by a negative charge. (4) Both vary with the temperature according to a formula of the type $a\theta^{1/2}e^{-b/\theta}$, where a and b are constants. (5) In neither case is there any simple relation between chemical action and thermionic emission; and (6) the kinetic energy of the thermions is much the same in both cases. A. E. G.

367. *Mobility of Positive Ions in Flames.* **S. G. Lusby.** (Phil. Mag. 22. pp. 775–791, Nov., 1911.)—The paper is a continuation of the work described in Abstract No. 648 (1911), the observations having been extended to flames at different temperatures. Two mesh electrodes are placed horizontally above one another in a Bunsen flame, and the current between them is measured for different p.d.'s—the upper plate being charged positively. A small bead of salt is then introduced into the flame just beneath the upper electrode, and the current measurements are repeated. When the p.d. is great enough to drive back the positive ions against the uprush of the gas, the current suddenly increases. The exact potential required is obtained by comparing the two current-curves. Knowing this critical voltage, the *minimum* electric force in the flame is obtained, and if the upward velocity of the flame gas is known a simple calculation gives the ionic mobility. The temperature of the flame was varied and observations were made from 1150° to 1950° abs. It was found that down to 1800° abs. all salts of all conducting metals produce the same ion; below this temperature the ion due to monovalent metals has a greater mobility than that due to divalent metals. Between 1950° and 1400° the mobility varies as the square root of the temperature, and corresponds closely to that calculated for a hydrogen atom. Below 1400° the mobility drops very rapidly, as if extensive clustering took place. E. M.

368. *Mobility of Positive Ions at Low Pressures.* **G. W. Todd.** (Phil. Mag. 22. pp. 791–804, Nov., 1911.)—In a previous paper [Abstract No. 642 (1911)] the author has shown that the mobility of the positive ions produced by means of X-rays in gases at low pressures obeys the inverse pressure law down to a few mm. of mercury. The experiments could not be carried further owing to the fact that the ionisation produced by X-rays becomes very feeble at low pressures. It is well known, however, that certain salts when strongly heated emit a copious supply of positive electricity, and the experiments have therefore been continued, using as a source of positive ions strongly-heated aluminium phosphate, with the object of measuring mobilities at much lower pressures. A modification of Rutherford's alternating-current method [see Abstract No. 642 (1911)] was used in some experiments, while in others the same principle was used, but the alternations of electric field were produced by a specially-designed rotating commutator. The values found for the mobilities at the higher pressures agreed with the previous determinations for the mobilities of the positive ions produced by X-rays, showing that the positive electricity emitted by the aluminium phosphate hands over its charge to the gas molecules on collision. Further results of the investigation were as follows: (1) The mobilities of the positive ions of the gases examined (air, CO_2, SO_2, H, CH_4) are inversely proportional to the pressures down to certain low critical pressures (air at 1·2 mm. Hg) approximately proportional to the densities of the gases, below which pressures the mobilities increase very rapidly. (2) The presence of water-vapour, which has very little effect on the mobility of the positive ion in regions where the inverse pressure law holds, has a big effect when the pressure is below that region, making the mobility less than that required by the inverse-pressure law. (3) Calculating the mass of the ion from the formula $k = e\lambda/mv$ gives numbers indicating that the ion consists at ordinary pressures usually of about six molecules, and in the case of hydrogen of about twelve, round the positive charge. These groups break up at low pressures, giving an increased mobility. (4) In the cases of air and CO_2 the measurements at the lowest possible pressures show that the positive charge is carried by something less than the molecule of the gas. This may be due to the existence of a universal positive unit, or it may be due to hydrogen which the Pt (used for heating the aluminium phosphate) probably contained. **E. M.**

369. *Canal Rays in Potassium, Rubidium, and Caesium.* **E. Goldstein.** (Deutsch. Phys. Gesell., Verh. 13. 21. pp. 972–973, Nov. 15, 1911.)—Records, with a diagram of the special tube used, the successful production of canal rays in the vapours of potassium, of rubidium, and of caesium. The experiment may be continued for some time without blackening the tube. [See Abstract No. 1286 (1910).] **E. H. B.**

370. *Determination of* e/m *for Canal Rays in Hydrogen.* **W. Hammer.** (Deutsch. Phys. Gesell., Verh. 13. 21. pp. 955–960, Nov. 15, 1911. Phys. Zeitschr. 12. pp. 1077–1080; Discussion, p. 1080, Dec. 1, 1911. Paper read before the 83. Naturforscherversamml., Karlsruhe.)—Canal rays produced in hydrogen at a pressure of about 5×10^{-3} mm. Hg were allowed to pass into a vessel at pressure 2×10^{-4} mm. Hg through a capillary tube, as in the experiments of J. J. Thomson [Abstract No. 658 (1911)]. The rays were first deflected by combined electric and magnetic fields, so that, owing to their inhomogeneity, parabolic patches of light were produced on a willemite screen placed in their path. By means of a universal spherical glass joint a small hole in the screen was adjusted to be on the parabola corresponding to H_+ (for example). In this way a pencil of rays of definite velocity was obtained, for any variation of the potential in the discharge tube did not alter the velocity of the rays coming through the hole, but only their intensity, owing to the hole occupying a different position on the parabola.

The pencil of homogenous rays so obtained was passed through two electric fields at right angles to and distant from one another. These electric fields were connected with the same source of alternating e.m.f. Thus the light produced by the rays on a screen placed beyond the electric fields assumed the form of an ellipse unless the time taken for the rays to travel the distance between the fields was equal to some simple multiple of the frequency of the alternating source, when the ellipse became a straight diagonal line. From the observations the author deduces the velocity of his canal rays to be $2{\cdot}51 \times 10^8$ cm. sec.$^{-1}$ and the value of e/m to be 10,040 which agrees within the experimental error with the value 9654 for the hydrogen ion in electrolysis.

E. M.

371. *Reflection and Secondary Radiation of Photoelectrically Liberated Kathode Rays.* **A. Gehrts.** (Ann. d. Physik, 36. 5. pp. 995–1026, Dec. 21, 1911. From Dissertation, Berlin.)—Lenard has shown that photoelectrically-liberated kathode rays can produce secondary radiations in gases and solids [Abstracts Nos. 2194 and 2958 (1904)]. He studied these phenomena by a phosphoroscopic method. His results show that in gases no marked secondary radiations occur when the primary velocity is under 11 volts, but about that velocity the quantity of secondary radiations suddenly increases, reaching a maximum in air at 800 volts and in CO_2 at about 500 volts primary velocity. The secondary radiation in both gases and solids is of very small velocity. He did not prove any reflection of the primary rays. More recently v. Baeyer [see Abstract No. 270 (1909)], working with slow kathode rays from a glowing oxide kathode, has shown a reflection of primary rays whose velocity lies between 10 and 15 volts. Experiments now described indicate that at a primary velocity of 11 volts a sudden change occurs in ratio of the reflected (secondary) to the incident radiation; while up to 11 volts this ratio gradually diminishes with increasing primary velocity, for velocities above that limit the ratio suddenly and rapidly increases. The secondary rays have a velocity of about 8 volts or less, and their quantity reaches a maximum with a primary velocity of 220 volts, after which it slowly decreases. The influence of reflection on the quantity—and velocity—distribution curve as well as the dependence of the sudden change in the curves on the reflected rays is also demonstrated.

A. E. G.

372. *Production of Light by Kathode Rays.* **G. S. Fulcher.** (Astrophys. Journ. 34. pp. 388–396, Dec., 1911.)—In a previous paper it has been shown that light is emitted as a result of the collision of canal rays with gas molecules, and that its intensity is proportional to the mean energy transmitted multiplied by the number of collisions [Abstract No. 510 (1911)]. An analysis of the Doppler-effect indicates that the neutral rays are far less effective than the charged rays in producing this luminescence. An attempt has been made to separate the charged from the uncharged rays, but, as found also by Wien and Koenigsberger, this proved unsuccessful, owing probably to the secondary ionisations produced during the discharge. Attention was then paid to secondary kathode rays, and a special apparatus constructed to allow of the spectral analysis of the fine stream of illumination proceeding from a minute hole in the plate. A series of reproductions are given showing the anode spectrum of the induced illumination by the secondary kathode rays in air, hydrogen, oxygen, and nitrogen. In nitrogen this spectrum consists solely of the negative bands. In hydrogen it consists chiefly of the compound spectrum together with the main series lines

relatively weak. In oxygen the spectrum shows the negative bands together with the spark lines and series of triplets. It is concluded that when kathode rays produce a band spectrum it may reasonably be assigned to the positively-ionised molecule of the gas. The negative bands of nitrogen and oxygen are probably emitted by the respective molecules as a result of ionisation by kathode rays. C. P. B.

373. *Entladungsstrahlen at Atmospheric and Diminished Pressures.* **E. R. Laird.** (Phys. Rev. 33. pp. 512–527, Dec., 1911.)—The experiments here described form a continuation of those carried out upon the ionisation produced by Entladungsstrahlen [see Abstract No. 711 (1910)]. One of the chief difficulties in experimenting with this radiation is that it is so readily absorbed by solid substances, and by using the thermoluminescent effect as a measure of the transmission it is not certain that any slight apparent transmission is not due to light. By using the ionisation effect with turpentine in the ionisation chamber for increasing the sensitiveness a number of substances have been found to transmit the radiation slightly. A list of these substances with details of the experiments is given. The penetrability under varying conditions is next studied. Various experiments indicate that the main effect must be in the air itself and is not influenced to any marked extent by the walls of the ionisation chamber. The other points investigated are: (*a*) the effect of various gases on the production of the radiation, the ionisation produced in these gases and the absorption which takes place in them. The gases used are hydrogen, oxygen, nitrogen, CO_2, and chlorine. (*b*) The radiation from the discharge in air at lower pressures. (*c*) The penetrability of the radiation at low pressures. (*d*) The source of the radiation. It is concluded that the radiation is not of a definite wave-length, since varying the capacity varies the relative effects produced on air and on turpentine vapour, and also varies its transmission by collodion films. The experiments help to confirm J. J. Thomson's general theory of the spark discharge and to show that the Entladungsstrahlen are an electromagnetic radiation with properties approaching those of light but differing from light in the lack of definite periodicity, and becoming more penetrating at lower pressures. A. E. G.

374. *Metallic Fatigue under Röntgen Rays.* **E. G. Rieman.** (Phys. Rev. 33. pp. 433–441, Nov., 1911.)—The recent work of More and Gowdy shows that metals subjected to Röntgen radiation suffer changes of secondary radiation in a manner somewhat similar to that found by Hallwachs in the case of metals acted upon by ultra-violet light. This action has been designated by the term fatigue. Thus, a freshly polished iron disc, under X-rays in air, gave, after 8 hours' exposure, a secondary radiation which was 4 per cent. *greater* than the original. Whereas lead, under the same conditions, showed a *decrease* of 8 per cent. Further, chemical change of the surface was needed for the fatigue to occur. Metals in CO_2 showed no fatigue. Discs whose surfaces were old and chemically stable showed no fatigue in air. The chief results of the present experiments may be summarised as follows: Fatigue occurred when freshly polished surfaces of iron, copper, tin, lead, and zinc were exposed to X-rays in the presence of oxygen or a mixture of oxygen and CO_2. Aluminium showed no appreciable change. The fatigue for metals in pure oxygen was practically equal to that which occurred when 50 per cent. of the CO_2 was present. Also the fatigues of all metals in Cl and CO_2 was practically of the same amount, although the percentage of the mixture was varied through rather wide limits. Old oxide surfaces, which are stable so far as fatigue in an atmosphere of oxygen is concerned, showed decided fatigue when tested in chlorine. In the case of iron in chlorine and oxygen, a double fatigue seemed to occur, one tending to increase, and the other to decrease, the radiation. Fatigue was found for metals with freshly-polished surfaces when exposed in chlorine, bromine, nitric acid fumes, hydrogen sulphide, and hydrochloric acid. [See Abstract No. 419 (1910).] E. H. B.

375. *Anode-fall, Kathode-fall, and Minimum Potential in Chlorine.* **R. Raisch.** (Ann. d. Physik, 36. 5. pp. 907–928, Dec. 21, 1911. Dissertation, Freiburg.)—Bode and Matthies found independently that the potential gradient in the glow discharge in chlorine is about three times greater than in other gases. Bode found the kathode-fall with Pt to be 827 volts, and Matthies 295 volts. For the anode-fall Matthies gives abnormally high values ranging between 182 and 851 volts. He pointed out a great dependence of this upon the pressure and current, but was unable to find any law connecting these quantities. From his results it is uncertain whether the high values of the anode-fall observed are actually present, or whether they are caused by impurities or the alteration of the electrode by the action of the chlorine. More recently [see Abstracts Nos. 96, 869, 1180 (1907), 845 (1908), and 1089 (1909)], Gehrcke and Reichenheim have concluded that just as the canal rays can be explained by the high kathode-fall, so the anode and A_1 rays are due to the high anode-fall. Reichenheim, using Al electrodes in chlorine, obtained an anode-fall of over 500 volts. In the present paper experiments are described, the results of which lead to the conclusion that with electrodes of pure Al, Pt, and magnetite the kathode- and anode-fall in chlorine are not essentially different from those observed in other gases. When the metal surface becomes altered through contact with chlorine, the kathode-fall, minimum potential, and, more especially, the anode-fall are increased. The surface of such an electrode can be purified by the energetic sputtering produced during the discharge, and then the potential falls.
A. E. G.

376. *Pulverisation of Metals by the Oscillating Discharge.* **J. de Kowalski and E. Banasinski.** (Archives des Sciences, 32. pp. 468–470, Dec., 1911.)—It has been shown that metallic electrodes employed in the production of an oscillating discharge of a condenser are pulverised. In descending order of degree of pulverisation the metals may be arranged as follows: Au, Pt, Zn, Fe, Cu, Ag, Al. It is now shown that the effect increases with the explosive distance whatever metal is used, and that it diminishes with the capacity, this latter being more pronounced for large than for small explosive distances.
A. E. G.

377. *Braun Tube and High-frequency Oscillations.* **H. Hausrath.** (Phys. Zeitschr. 12. pp. 1044–1046, Nov. 15, 1911. Paper read before the 83. Naturforscherversamml., Karlsruhe.)—A Braun tube is here used for the investigation of high-frequency oscillations as follows:—A Lissajous figure is produced on the fluorescent screen by combining, with the motion due to the oscillation under investigation, a perpendicular motion due to a pure sine oscillation in a supplementary circuit tuned to and very loosely coupled with the first circuit. The supplementary circuit has large self-induction and small capacity, and deflects the kathode beam electrostatically. Instead of

an electrical machine, an induction coil is used to produce the discharge in the tube. A large condenser is charged up from the induction coil by a needle point and plate valve, and this condenser discharges itself through the tube and an alcohol resistance in series. A special tuning-fork interrupts the primary current of the induction coil. T. P. B.

378. *Resistance of Solenoids to Electrical Oscillations.* **K. Herrmann.** (Deutsch. Phys. Gesell., Verh. 13. 21. pp. 978–988, Nov. 15, 1911.)—At low frequencies a stranded cable does not show the increase in resistance which a massive wire does, but at high frequencies Lindemann found that a coil of massive wire may have a lower resistance than one of stranded cable, wire and cable having the same cross-section of copper [see Abstracts No. 1187A (1910); 1187B (1911)]. The author substantiates the truth of this observation by a calorimetric method. The two coils, of exactly the same resistance to continuous current, are placed in calorimeters filled with paraffin oil, and the ratio of the resistances of the two coils is determined from the expansion of the oil, which is read off on capillary tubes. It is found that as the frequency is increased, the ratio of the resistance of the coil of massive wires, to that of stranded cable decreases. T. P. B.

379. *Wave Interference without Path Difference.* **F. Aigner.** (Akad. Wiss. Wien, Ber. 120. 2a. pp. 588–609, April, 1911.)—The desired phase-difference is here obtained "by the right choice of the possible vibration forms of a resonator vibrating in a half wave-length as its fundamental vibration." Thus wave interference is obtained by phase-difference without any path-difference. This principle is applied to electric waves and to sound waves, the details being explained by over twenty figures. E. H. B.

380. *Speed of Electric Waves along Wires.* **C. Gutton.** (Comptes Rendus, 153. pp. 1002–1004, Nov. 20, 1911.)—Describes an improvement in precision of the method formerly adopted to compare the speeds of light in air and of electric waves along wires. The test is made by the light from a spark on the wire system proceeding through crossed nicols between which carbon disulphide is placed and made doubly refracting by the Kerr-effect from a connection at another point on the wire system. Hence the light only passes if the carbon disulphide is doubly refracting at the right instant. The adjustment is made to effect this, and the corresponding distances of light path and electric wave path are read. [See Abstract No. 781 (1911).] E. H. B.

381. *Influence of Electrode Material on Arc-formation in Oscillation Circuits.* **K. Rottgardt.** (Phys. Zeitschr. 12. pp. 1160–1162, Dec. 8, 1911.) A continuation of work already published [see Abstract No. 1889 (1911)]. Here different metals are used for the spark-gap electrodes, and, everything else remaining constant, the current in the primary of the transformer is regulated until the arc changes to a spark. The smaller the primary current when the change takes place, the more is the metal inclined to form an arc. The results show that those metals which are most suitable for "impact" excitation give rise most readily to an arc discharge. The effect of the gas surrounding the spark-gap is also investigated. The discharge is most inclined to take the form of an arc in hydrogen, and least in air. The series is H, O, CO_2, air. T. P. B.

382. *Bending of Electric Waves round a Large Sphere.* III. and IV. **J. W. Nicholson.** (Phil. Mag. 21. pp. 62–68, Jan., and pp. 281–295, March, 1911.)—A continuation of the work dealt with in Abstract No. 1828 (1910). Part III. deals with the determination of the constant β; with application to wireless telegraphy. Part IV. is concerned with the evaluation of a type of integral. L. H. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

383. *Light-negative Selenium.* **L. B. Crum.** (Phys. Rev. 33. pp. 538–548, Dec., 1911.)—A selenium bridge (or "cell") made by F. C. Brown [Abstracts Nos. 1490 (1910); 1568 (1911)] showed a slight (1 per cent.) increase of resistance on exposure to light. It had a resistance of only 800 ohms with a surface of about 2 cm.^2. The exposure and recovery curves are very similar to those of light-positive selenium, but reversed. Change of conductivity increases with the intensity of the light, in nearly the same proportion as in normal bridges. With a faint light most of the change takes place within the first few seconds of exposure. The longer the selenium has been exposed the less complete is its recovery within a given time. Sensibility of the light-negative Se borders so close on the normal sensitiveness that a slight stimulus may change its sign. It seems to inhere in the Se itself, and not to be due to impurities. No sure method of producing light-negative Se could be devised. E. E. F.

384. *Theory of Action of Selenium.* **F. C. Brown.** (Phys. Rev. 33. pp. 403–420, Nov., 1911.)—A further essay on the chemical theory of selenium [see Abstract No. 1568 (1911)]. Only one of the three components is conducting, and light has no action on the reverse changes. The theory was corroborated to some extent, and its constants determined, by a detailed study of the fatigue and recovery of a Giltay "cell" at 18°, 28°, and 52° C. respectively. The rapid change taking place during recovery is not altered much by temperature. The recovery attained after a given exposure within 0·1 sec. was determined by means of Brown and Clark's method for measuring fluctuating resistances. The percentage recovery hardly varies as much as 1 per cent. when the exposure varies from 0·4 sec. to 240 sec. The time required for reaching the max. conductivity during exposure increases when the light decreases in intensity. A curve is given showing the rate of recovery from exposure to a p.d. of 152 volts. E. E. F.

385. *Unidirectional Conductivity of Contact Detectors.* **G. Leimbach.** (Phys. Zeitschr. 12. pp. 228–231, April 1, 1911.)—The author gives the results of some experiments with a Te-Si combination. When tested for the rectifying effect this gave, with Te positive and Si negative, values for the apparent resistance ranging from 2,830,000 ohms down to 818,000 for values of the applied direct-current voltage ranging from 0·14 to 0·98. With Te negative and Si positive the corresponding values were 2,000,000 down to 2120 ohms for p.d.'s of 0·14 to 4·2 volts. Next the effect of an auxiliary applied voltage was examined, the detector being excited by electric oscillations. In this case for auxiliary voltages from 0 to 0·697 and "rest" currents of 0×10^{-8} up to 198×10^{-8} the current when excited ranged from 58×10^{-8} up to 880×10^{-8}. In the reverse direction (Te negative) the corresponding figures were: 0 — 2·94 volts; 0×10^{-8} to 8640×10^{-8} "rest" current; current excited, -80×10^{-8} to $+18{,}240 \times 10^{-8}$ amp. The counter-e.m.f. appears to have a value between 0·6 and 0·7 volt; the initial current (-80×10^{-4}), arising from the excitation, without auxiliary voltage, flowing in the opposite direction to that of the rest current. **L. H. W.**

386. *Electrical Conductivity of Radium D.* **L. Kolowrat.** (Le Radium, 8. pp. 401–404, Nov., 1911.)—When RaEm disintegrates it ultimately becomes converted into RaD owing to the long period of the latter. The author calculates that it should be possible to obtain from the emanation in equilibrium with 0·25 gm. Ra a sufficient quantity of RaD on the glass walls of a small vessel to give an electrical resistance of the order 40 ohms. The present experiments aimed at an estimation of this resistance, but a negative result was obtained, no increase in the conductivity of the walls of an emanation tube being found. The absence of effect was traced to the active deposit not being uniformly distributed, the lack of uniformity being due to the shape of the tube and the unavoidable presence of the electrodes. **E. M.**

387. *Electrical Resistance of Iron Alloys.* **C. F. Burgess** and **J. Aston.** (Amer. Electrochem. Soc., Trans. 20. pp. 205–222; Discussion and Communication, pp. 222–224, 1911.)—A knowledge of the electrical resistance of iron alloys is of interest because of their possible use in rheostats and electric heaters, and in the case of magnet alloys the resistivity is of importance second only to the permeability. Starting with electrolytic iron as a base material, the authors have prepared and investigated upwards of 300 binary, ternary, and complex alloys of iron in various physical states, the resistances being compared with that of forged and quenched electrolytic iron as unity. Al, Sb, As, Cr, Mn, Ni, Se, Si, and Sn largely increase the resistance of iron, accompanied, in the case of As, Si, and Sn, by the highly desirable increase in the magnetic permeability. A chromium alloy with 16·57 per cent. of Cr has a relative resistance of 4·18. Nickel increases the resistance slowly up to a content of about 22 per cent., but in the region of non-magnetic alloys there is a rapid rise to a maximum of 6·77 between 28·42 and 35·09 per cent., when the resistance again falls. It is possible that the maximum is situated at 34 per cent. at which there exist discontinuities in other properties, corresponding to the compound Fe_3Ni. Cobalt, Cu, Pb, Mo, and W increase the resistance only very slightly, while the effect of Ag and Bi is doubtful. In the ternary alloys the highest resistances are obtained with the Ni-Cr alloys, while in complex alloys combinations of Fe with Ni, Cr, and Si give the highest results. Annealing usually decreases, and quenching increases, the resistance. **F. C. A. H. L.**

388. *New Data on Electrical Properties of Sodium, Potassium, and their Alloy.* **E. F. Northrup.** (Amer. Electrochem. Soc., Trans. 20. pp. 185–203; Discussion, pp. 203–204, 1911.)—To remedy the scantiness of data regarding the electrical properties of metals at elevated temperatures, the author has undertaken a systematic investigation of the resistivities and temperature-coefficients of metals and alloys, starting with sodium and potassium. The measurements were made over a range of from 0 to 150° C. in terms of pure mercury whose resistance is almost a rectilinear function of the temperature, the equation over this range being $R_t = 0·02899\ (1 + 0·0010036t)$. Sodium in passing from the solid state at 93·5° to the liquid state at 98·3° C., increased in resistance by 44·8 per cent.; potassium increased 52·2 per cent. between 60·4° and 63·2°, while an alloy of equal volumes of Na and K increased 48·5 per cent., its range of melting being taken as from 2·8° to 20° C. The resistances of the alloy are very much higher at all temperatures than the mean of the resistances of pure Na and K. By observing the resistance on both heating and cooling, loop curves are obtained, the loops being attributed to lag caused by expansion and contraction. Taking the values of the resistivities of mercury as $95{,}782 \times 10^{-9}$ and $108{,}560 \times 10^{-9}$ at 20° and 100° C. respectively, the values for sodium, potassium, and the alloy are as follows :—

	At 20° C.	At 100° C.
Specific resistance of sodium	4878×10^{-9}	9724×10^{-9}
„ potassium ...	7116×10^{-9}	15806×10^{-9}
„ alloy... ...	$38{,}792 \times 10^{-9}$	$37{,}872 \times 10^{-9}$

F. C. A. H. L.

389. *Resistance of Alloys.* **J. Clay.** (Jahrbuch d. Radioakt. 8. pp. 388–406, Nov. 16, 1911.)—According to a theory of Rayleigh the additive electric resistance of an alloy may have a thermoelectric origin. If the alloy is assumed to consist of thin layers of the pure metals at each point of contact, Peltier-effects will arise which will cause alternate heating and cooling, and these temperature changes will cause a thermoelectric current which will oppose the original current and have the same effect as an increased resistance. Measurements of the thermo-e.m.f. of gold-silver, and of the resistance of some gold-silver alloys, indicate that this theory of Rayleigh and Liebenow is not tenable. It is possible that in the case of alloys the collisions of the free electrons with the detached atoms of the metals may be the cause of the additional resistance. J. J. S.

390. *Electrical Resistivity of Special Steels.* **O. Boudouard.** (Comptes Rendus, 153. pp. 1475–1478, Dec. 26, 1911.)—The author has determined the resistance of nickel, manganese, chromium, and tungsten steels by Kelvin's method. Two series of alloys with each metal were made, one containing 0·1 to 0·2 per cent. C, and the other 0.8 to 0·9 per cent. C, the general results being as follows :—In carbon steels the resistance increases with the carbon-content. With constant Ni, carbon considerably increases the resistance, and the curve passes through a maximum approximately corresponding to the formula $NiFe_2$. Carbon appears to have very little effect on the Mn steels, otherwise there appears to be a maximum corresponding to 12 to 13 per cent. Mn. In the chromium series irregularities arise regardless of the carbon-content. The resistances of tungsten steels are not affected to any considerable extent by the state of the metal (hard, annealed, or ordinary), but the curve appears to pass through a maximum, then through a minimum, and finally increases rapidly. Application of Benedicks' formula to the carbon steels gives results in good agreement with the observed figures, but the formula does not apply to special steels except in indicating the specific influence of a metal on the resistance of the steel under consideration.

F. C. A. H. L.

391. *Insulating Power and Kerr-effect of Liquid Air.* **P. Zeeman.** (Konink. Akad. Wetensch. Amsterdam, Proc. 14. pp. 650–655, Jan. 24, 1912.)—The experiments described confirm the results previously obtained by Fleming and Dewar, showing the high insulating power of liquid air for potentials up to about 30,000 volts; the existence of the Kerr electro-optic effect was also established, and it was found that the Kerr constant of liquid air (oxygen) is about 20 times smaller than that of CS_2, and, as in CS_2, the effect is positive. Light from an arc lamp was sent through a nicol, then in succession through a compensator, the vacuum vessel with small liquid-air condenser, a second nicol, and was finally analysed by means of a low-dispersion spectroscope. Difficulty was experienced in finding a portion of the vacuum tube with the four walls unstrained. The field of the spectroscope showed the continuous spectrum with the vertical absorption bands due to oxygen, and an approximately horizontal dark band, which was displaced downwards on charging the condenser, and jumped back to its original place at a discharge of the condenser. No singular behaviour was observed near the absorption bands. A. W.

392. *Peltier Electromotive-force.* **A. E. Caswell.** (Phys. Rev. 33. pp. 379–402, Nov., 1911.)—The Peltier e.m.f. was redetermined for a number of combinations. Two methods of measurement were used, both of which depend upon maintaining both junctions of the given couple at the same temperature by supplying heat at the junction where cooling is taking place. This precludes the possibility of error arising out of other thermoelectric effects. The Peltier e.m.f. is determined by measuring the ratio of the heat so supplied to the quantity of electricity sent across the junction. In the first method the two junctions of the couple were placed in two separate calorimeters containing equal quantities of a suitable liquid. Each was provided with an electric heating-coil of known resistance, by means of which sufficient heat was supplied to the liquid where cooling took place to maintain it at the same temperature as that where heat was evolved, the equality of temperature being shown by a differential thermometer. The second, or shunt-current, method differed from the first in that compensation was accomplished by sending more current through one of the junctions than through the other, the difference in the Joule heating-effect being equal and opposite to that arising out of the Peltier-effect. The values found for the Peltier e.m.f. for the couples investigated are as stated in the following table:—

Metal against Copper.	Peltier e.m.f. in Millivolts.	Temperature.
—		
Copper	—	—
Silver	0·03	18° C.
Aluminium	0·70	16
Platinum	0·85	17
Nickel	6·0	22
Bismuth	16·1	18
+		

In order to test the validity of Thomson's theorem that $P = T \,.\, dE/dT$, where P is the Peltier-effect and E the thermo-e.m.f. at absolute temperature T, the thermo-e.m.f. of the various couples was measured. The values of P calculated from the formula in general agreed approximately with the values found from experiment. [See also Abstract No. 1222 (1911).] J. J. S.

393. *Thermoelectric Behaviour of Heusler Alloys in a Magnetic Field.* **L. O. Grondahl** and **S. Karrer.** (Phys. Rev. 33. pp. 531–537, Dec., 1911.)—The effect of a magnetic field on the thermoelectric behaviour of Heusler alloys was studied by the same method as that employed by Guthe and Austin [Abstract No. 1921 (1906)], but with a more sensitive arrangement of the apparatus. The alloys employed were those used by Knowlton in a previous research [Abstract No. 584 (1911)], and the experiments show that the effect of the magnetic field on the thermoelectric behaviour is of the same nature as in the case of Fe, Ni, and Co. In this respect then the alloys exhibit no difference from the common magnetic materials. The fields employed gave in the case of Zn and Al no effect as great as 10^{-7} volt with fields up to 2800 gauss. The thermo-couples were in all cases formed of a sample of the metal under test and copper in the form of No. 18 wire. The junctions were maintained at 0° and 100° respectively. While the effect occurs in all the alloys tested, there seems to be no definite relation between the magnitude of the effect and the magnetic quality of the alloys. A. D. R.

394. *Contribution to the Theory of the Induction Coil.* **R. Hiecke.** (Elektrotechnik u. Maschinenbau, 30. pp. 69–77, Jan. 28, 1912.)—The theory applies to a coil which is worked with a mercury interrupter and a condenser in the primary, and is concerned chiefly with the p.d. in the secondary, on which the spark-length depends. Starting with the equations for the e.m.f. in primary and secondary at the instant at which the primary is broken, expressions are found for the max. attainable p.d. in the secondary, the period of the oscillations, and other magnitudes. The experimental data at hand, due to the author, Klingelfuss and others, are considered by the author as insufficient to completely confirm the expressions obtained, but they make their accuracy very probable. The conclusions of Klingelfuss [Abstract No. 1717 (1901)] are not in agreement with those of the author. One of the practical results obtained shows that the use of fine iron wires in the core is favourable to the working of the coil. G. E. A.

395. *Moving-coil Galvanometer as Substitute for the Electrometer.* **W. Peukert.** (Elektrotechn. Zeitschr. 32. pp. 862–863, April 13, 1911.)—The author points out that an ordinary galvanometer with moving coil can be used as an electrometer, the coil system and the magnet system of the former being equivalent to the needle and the quadrant system, respectively, of the latter. But the sensibility obtained when the moving coil is at its normal reading (zero) is very small. In order to avoid the necessity of bodily turning the coil system with its suspension and supports, the author arranges for a small direct current to pass through the coil so that the latter is deflected from its normal (zero) reading; and the applied p.d. between the magnet system and the coil is used to reduce this initial deflection. It is advisable to place a condenser in series with the galvanometer to reduce the chances of a breakdown. A typical calibration curve is given in the original.

L. H. W.

396. *Sensitive Moving-coil Galvanometer of Low Resistance.* **H. Zahn.** (Zeitschr. Instrumentenk. 31. pp. 145–148, May, 1911.)—The author considers the difficulties in the way of obtaining a sensitive moving-coil galvanometer, and compares his galvanometer with similar ones made by Siemens and Halske, and by Hartmann and Braun. He points out that the greatest difficulty is experienced in keeping the resistance of the coil leads low without at the same time increasing the restoring couple. The author's galvanometer has a resistance of 4·7 ohms; the coil consisting of a single layer of 15 turns of length 6·6 cm. and width 1·55 cm., has a resistance of 1·58 ohms. The period on open-circuit is 4·2 sec. and the pressure sensitiveness is $2{\cdot}8 \times 10^{-8}$ volt. W. C. S. P.

397. *Arrangement for Measuring Direct and Alternating Current over Wide Ranges, and for Protecting a Sensitive Galvanometer against Overload.* **Rudolph.** (Elektrotechn. Zeitschr. 32. pp. 1055–1056, Oct. 19, 1911.)—The procedure consists in placing on a balanced bridge a calibrated thermo-element system. The heating action of the current to be measured gives rise to a thermoelectric current which can be measured in terms of the deflection of moving-coil galvanometers. The arrangement can be calibrated by means of direct current by putting a milliammeter in the heating circuit. The sensitiveness is varied by making use of two galvanometer coils, one of 5 ohms, the other of 100 ohms' resistance. W. C. S. P.

398. *Apparatus for Demonstrating Alternating-current Phenomena.* **B. Glatzel.** (Phys. Zeitschr. 12. pp. 1069–1072; Discussion, pp. 1072–1073, Dec. 1, 1911. Paper read before the 83. Naturforscherversamml., Karlsruhe.)—This comprises a small induction motor the rotor of which carries, in addition to its squirrel-cage winding, a special single-phase winding connected to slip-rings. The rotor runs on ball bearings. Mounted on the shaft are an eddy-current brake and a vane which acts as an air-brake, both of which can be finely adjusted. When the stator is supplied with polyphase currents the speed of the rotor can be accurately controlled and maintained uniformly by means of these brakes. Hence the frequency of the e.m.f.'s in the extra rotor winding can be made any desired submultiple of the primary frequency. In conjunction with this machine a Braun tube is used, the spot of light being intensified and made sharper by the employment of a longitudinal magnetic field as described by Diesselhorst. Mounted with the tube are two coils whose axes are transverse to the ray. One of these is connected to the primary circuit, and the other to the slip-rings. When the axes of the coils are set at right angles to each other, various forms of Lissajous' figures are described on the screen, according to the speed of the rotor. Further, when the coils are placed with their axes in line with each other and an image of the spot is focussed on a moving photographic plate, surging waves can be shown. In the *discussion*, **Diesselhorst** said he had obtained Lissajous' figures with a Braun tube arranged in this way, by connecting the two coils in differently tuned circuits fed from a Poulsen arc.

F. T. C.

ALTERNATING CURRENTS AND MAGNETISM.

399. *Production of a Homogeneous Magnetic Field.* **A. Bestelmeyer.** (Phys. Zeitschr. 12. pp. 1107–1111, Dec. 1, 1911. Rev. Électrique, 17. pp. 281–283, March 22, 1912.)—The author discusses the problem of constructing a solenoid of diam. as great as 40 per cent. of its length and such that the field within it is approximately uniform. The intensity of the field at any point within a cylindrical magnetising coil is developed as a series, and hence it is shown that by inserting two small additional coils within the solenoid, one near either end, it is possible to obtain a very homogeneous field. The paper describes how a coil was constructed in this way, the main solenoid being 68·72 cm. long and with inner and outer radii of 13·3 and 15·75 cm. The subsidiary coils were each 11·692 cm. long, and 9·89 and 11·78 cm. internal and external radius respectively. When the two subsidiary coils were placed symmetrically in the main coil and separated by a distance of about 55 cm. there was a very uniform field throughout the centre 20 cm. length of the solenoid. At points in this region and on the axis of the coil the intensity of the field varied by less than 1 part in 500. At points within 8 cm. of the axis and a like distance from the centre the maximum variation was also within 1 part in 500. The paper concludes with a description of a differential method by which the slight variations in the field were investigated with the aid of an Edelmann Deprez-galvanometer. A. D. R.

400. *Paramagnetism at very Low Temperatures.* **H. Kamerlingh Onnes** and **A. Perrier.** (Konink. Akad. Wetensch. Amsterdam, Proc. 14. pp. 674–678, Jan. 24, 1912. Communication No. 124a. from the Phys. Lab., Leiden.)—The paper deals with the susceptibilities of solid oxygen and of anhydrous ferrous sulphate and their deviations from Curie's law. In the case of solid oxygen it is found that the susceptibility remains practically unchanged as the temperature sinks from the boiling-point to the freezing-point of hydrogen, and apparently thereafter decreases. In the course of the experiments it became evident that there is a considerable and sudden change in the susceptibility of oxygen on melting and freezing. The values of the susceptibility of solid oxygen found by the attraction and torsion methods differ very appreciably, and the authors ascribe this to the substance possessing magneto-crystalline properties. The anisotropy of the oxygen would affect least the attraction experiments. With anhydrous $FeSO_4$ it was found that the susceptibility at higher temperatures increased, and at lower temperatures diminished, as the temperature was lowered. There is a well-marked maximum of the susceptibility. The authors conclude from these and former experiments [see Abstract No. 1282 (1911)], (i) that for all paramagnetic substances there exists a region of higher temperature within which deviations from Curie's law are insignificant, (ii) that as the temperature sinks lower the deviations increase until a max. susceptibility is reached, (iii) that thereafter the susceptibility decreases and tends to O at absolute zero. This generalisation renders it probable that for all paramagnetic substances the temperatures at which they show the same deviations from Curie's law are proportional to the temperatures of max. susceptibility of the substances. A. D. R.

401. *Magnetic Properties of the Elements.* **M. Owen.** (Konink. Akad. Wetensch. Amsterdam, Proc. 14. pp. 637–644, Jan. 24, 1912.)—The paper gives details of the saturation susceptibilities of 58 elements at ordinary room temperature, and of the variation of this quantity with temperature. Many of the elements were comparatively rare and probably contain a certain amount of impurity. Accordingly the values found for specimens obtained from different sources vary considerably. The work is in continuation of that described in a previous paper [see Abstract No. 786 (1910)], and an attempt is made to combine all the results with a view to obtaining some generalisations regarding the elements. The curve of susceptibilities of the elements as a function of their atomic weights is found to be very intricate, and there is great uncertainty regarding many solid elements such as Mn. There is also the trouble of polymorphism, and the choice of the allotropic form to be considered offers difficulty. The result found for Be in the present research adds a new negative peak to the curve, which divides itself into three analogous parts. The curves of susceptibility as a function of the temperature show most varied aspects. Roughly speaking the elements fall almost equally among the six possible classes, viz., paramagnetic and diamagnetic, each constant, increasing, and decreasing with temperature-rise. The thermomagnetic properties, like the magnetic, show a certain correlation with the periodic system. A. D. R.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

402. *Chemical Action of α- and β-Rays.* **F. L. Usher.** (Jahrbuch d. Radioakt. 8. pp. 323–334, Nov. 16, 1911. From the English.)—The author has examined the single and combined action of the α- and β-rays of RaEm and its products on the decomposition of water. A known volume of RaEm was sealed in a thin glass capillary surrounded by water and the action of the β-rays escaping from it was measured by the amount of electrolytic gas produced during the course of a month, in which time the emanation was almost completely transformed. The combined α- and β-ray effect was measured by dissolving the emanation in water and again observing the production of electrolytic gas. From the data it is calculated that the amount of gas produced by the α-particles is twenty times that produced by the β-particles. Owing to the large number of δ-particles which are known to accompany α-particles the author concludes that the whole effect can be ascribed to electrons, suggesting that decomposition is not due to bombardment. Further experimental results are given which show that water requires three times as great an amount of energy for its decomposition as is required by ammonia.
E. M.

403. *The Melting of Carbon by the Joule-effect.* **M. La Rosa.** (Ann. d. Physik, 36. 4. pp. 841–847, Dec. 7, 1911. N. Cimento, 2. Ser. 6. pp. 418–424, Dec., 1911.)—The author doubts that Watts and Mendenhall [see Abstract No. 1402 (1911)] took proper precautions to purify their carbon, and that they attained the high temperatures which he did. He regards with Tammann the amorphous state as a phenomenon of under-cooling and melting as a gradual diminution of viscosity, and maintains that his carbon did begin to melt—not at the surface and at atmospheric pressure, but in the interior and under the higher pressure and temperature prevailing there. H. B.

404. *Transformation of Carbon into Graphite.* **W. C. Arsem.** (Amer. Electrochem. Soc., Trans. 20. pp. 105–118; Discussion, pp. 118–119, 1911. Chem. News, 105. pp. 38–40, Jan. 26, and pp. 50–53, Feb. 2, 1912.)—The author puts to experimental test the views of Moissan (high temperature will suffice to convert amorphous carbon into graphite), Berthelot (high temperature not sufficient), and Acheson (graphite is the result of intermediate formation and decomposition of carbides due to the presence of mineral matter as original constituent or purposely added) by heating pure carbon, alone or with additions, and by removing all mineral matter from impure carbon. All the samples were ground to very fine powder, and fired up to 3,300° C. in a crucible, contained within a larger crucible in a tubular furnace, all of Acheson graphite. Pure petroleum coke gave a good graphite of density 2·26, and the addition of iron oxide proved rather disadvantageous. Bituminous coal coke gave a hard graphite of density 2·2; when first treated with NaOH, H_2O and HCl, the density rose to 2·25, so that here again the smaller the amount of mineral matter, the higher the density of the product. With anthracite coal the density of the product did not rise above 1·18. Lampblack gave a product of density 2·09; when 5 per cent. of Fe_2O_3 was present (precipitating the lampblack with ferric hydrate), the density did not rise above 2·12. White and grey retort carbon yielded graphite (density 2·265), black retort carbon did not. White diamonds turned into coke of density 1·915, not into graphite. Thus different forms of carbon may or may not yield a graphitic product; the limiting density of the product is not raised by the addition of small amounts of mineral matter. All these products give more or less graphitic oxide or acid in the Brodie test, which is, therefore, not strictly characteristic of graphite. The author would define graphite as the allotropic form of carbon having the density 2·25 or 2·26, probably of a not very complex molecular configuration. Diamond would be another allotropic form. Amorphous carbon would be the decomposition product of organic substances, probably of a very complex nature, a mixture of varieties of molecules, some of them being capable of undergoing rearrangement into graphite molecules under the influence of heat. **C. A. Hansen** mentioned experiments with a graphite kathode in a reversed mercury arc. H. B

405. *Diffusion of Neon through Hot Quartz.* **O. W. Richardson** and **R. C. Ditto.** (Phil. Mag. 22. pp. 704–706, Nov., 1911.)—In the course of some experiments undertaken to try to detect the presence of the heavier inert gases in minerals it was observed that Ne diffuses through red-hot quartz tubes. In order to ascertain whether the Ne which is observed to be present when some witherite is heated actually comes from that mineral, a new silica-ware tube which contains no foreign impurities is exhausted and heated for about 1 hour; the gas is then drawn off and examined. It is found to give a faint "blue argon" spectrum with the yellow He line. After about three hours' heating the He spectrum is fully developed, and the strong Ne line at 5852 is well marked. The tube is then left hot all night. Next morning the He and Ne spectra are both quite strong, all the prominent lines being easily recognised. There is, however, no definite increase in the intensity of the blue Ar spectrum, so that the He and Ne cannot have leaked in at the joints of the tube. From this it is clear that Ne diffuses through quartz at about 1000° C., but its coefficient of diffusion is smaller than that of He, since the spectrum of the latter is visible first, while there is ten times as much Ne as He present in the air. It is suggested that an easy method of measuring the amounts of He and Ne present in the air might be based on this property of diffusion through heated quartz. A. E. G.

406. *Application of Evaporation to the Measurement of Coefficients of Diffusion.* **P. Vaillant.** (Journ. de Physique, 1. Ser. 5. pp. 877–891, Nov., 1911.)—Formulæ are given for the rate of evaporation of a liquid in terms of the diffusion-constant of the vapour. The evaporation proceeds according to a regular law, the observed figures agreeing very well with those calculated over considerable periods of time. The absolute values of the diffusion-constant can be calculated in two ways and agree satisfactorily with those deduced by other methods. T. M. L.

407. *The System: Iron-Carbon.* **A. Smits.** (Konink. Akad. Wetensch. Amsterdam, Proc. 14. pp. 580–586, Dec. 28, 1911. Zeitschr. Elektrochem. 18. pp. 51–54, Jan. 15, 1912.)—The view that the occurrence of cementite in the iron-carbon system is a metastable one does not solve the problem of the production of cementite at temperatures far below the eutectic temperature, as in the case of Royston's experiments on annealing malleable iron. Since by varying the rate of cooling, graphite or cementite can be deposited from the liquid, the author assumes that both cementite and graphite are present in internal equilibrium [see Abstract Nos. 690, 691 (1911)]. Slow cooling brings about the deposition of graphite, and the liquid never becomes

supersaturated with respect to cementite. On the other hand, rapid cooling prevents the separation of graphite by supercooling, and the liquid becomes relatively supersaturated with respect to cementite, which then separates. Similarly, the martensite solid solution consists of solutions of graphite and cementite in iron existing in internal equilibrium. The effect of heating malleable cast iron to a temperature above 700° C. is to set up a stable equilibrium between graphite and the solid solution at that temperature. On cooling, the formation of graphite is suppressed by supercooling in a manner similar to the above. The production of graphite would require such extremely slow cooling that a thermal determination of the stable equilibrium between graphite and martensite would be quite impossible. The use of a powerful catalytic agent and the employment of dilatometric methods might possibly yield reliable results. F. C. A. H. L.

408. *Porosity of Iron and its Relation to Passivity and Corrosion.* **J. A. N. Friend.** (Chem. Soc., Journ. 101. pp. 50–56, Jan., 1912.)—Pieces of Kahlbaum's pure iron-foil were immersed in 6-N caustic soda for 3 weeks, washed until the washings were free from soda, and then immersed in a small quantity of distilled water. After 24 hours' immersion the presence of Na in the water was well marked. Similar experiments with potash showed the presence of potassium after 48 hours' immersion. Samples treated with potash were still passive after polishing with emery. Pickled samples, even though subsequently soaked in alkali, corroded more rapidly than the metal simply polished. These experiments indicate that there are several kinds of passivity, that induced by caustic alkalies being different from that induced by nitric acid, &c. The author concludes that iron is porous and capable of absorbing certain solutions, such as caustic alkalies, which prevent corrosion, and pickling acids and the salts produced by their neutralisation, which promote corrosion. Passivity induced by caustic alkalies is dissipated by boiling in water for half an hour. F. C. A. H. L.

409. *Mechanical Production of Rust.* **H. L. Heathcote.** (Engineer, 113. p. 80, Jan. 19, 1912.)—In this letter the author reports the occurrence of brown films and powder on parts of a motor-bicycle engine subjected to impact. A number of such parts were polished, exposed to a stream of hot alcohol for 5 hours, heated to 115° C. for 1½ hours to eliminate moisture, and while still hot were fitted in a hot engine. After running 5 minutes at 1750 impacts per min. all the parts exhibited films varying from brown to blue in colour. The films are readily soluble in hydrochloric acid, and appear to be oxide of iron. **A. S. Cushman.** (Ibid. p. 80, Jan. 19.)—Cushman believes the effect to be due to electrolysis between two metals of different constitution consequent upon the extreme difficulty of removing the last traces of moisture from between two surfaces in close contact. Corrosion between two oiled surfaces is probably brought about by the presence of traces of moisture in the oil.
F. C. A. H. L.

410. *Temperature-coefficient of the Electrical Conductivity of Hydrogen Chloride in Alcohol.* **J. R. Partington.** (Chem. Soc., Journ. 99. pp. 1937–1941, Nov., 1911.)—The conductivities of alcoholic solutions of hydrogen chloride at 0° and 18°, together with those previously determined at 25°, give for the limiting molecular conductivity, and for its temperature coefficient a, the values: λ_∞ at $0° = 46{\cdot}50$; λ_∞ at $18° = 60{\cdot}00$; λ_∞ at $25° = 66{\cdot}50$: a_∞ (mean) $= 0{\cdot}0178$. T. M. L.

411. *Conductivity of Mixtures of Copper Sulphate and Sulphuric Acid.* **H. K. Richardson** and **F. D. Taylor.** (Amer. Electrochem. Soc., Trans. 20. pp. 179–184, 1911.)—Addition of copper sulphate to solutions of sulphuric acid increases the conductivity of the mixture if the sulphuric acid is less than 3 gm. per 100 c.cm., but decreases the conductivity of the mixture if the sulphuric acid is over 3 gm. per 100 c.cm. The temperature-coefficient of mixtures of equal parts copper sulphate and sulphuric acid appears to be that of the sulphuric acid alone. T. M. L.

412. *Solubility of Actinium Emanation in Liquids and Charcoal.* **G. v. Hevesy.** (Phys. Zeitschr. 12. pp. 1214–1224, Dec. 15, 1911.)—By passing a current of air charged with actinium emanation through various liquids, the author shows that the following are in ascending order as regards solubility of actinium emanation: Saturated solution of KCl, water, concentrated H_2SO_4, ethyl alcohol, amyl alcohol, acetone, benzol, toluol, petroleum. This is also the order of solubility for both thorium and radium emanations. [See Boyle, Abstracts Nos. 1059 (1910), 410 (1911).] The coefficients of partition (Henry's law) of the emanations between water and air at room temperature are deduced as follows: ActEm, 2; ThEm, 1; RaEm, 0·3. The coefficients of partition between cocoanut charcoal and air were deduced to be: ActEm $>$ 20 at 18° C., ThEm $>$ 50 at 18° C., at Em, 100 at 10° C.

E. M.

413. *Mechanism of Osmosis.* **E. Fouard.** (Comptes Rendus, 153. pp. 1152–1155, Dec. 4, 1911.)—The author maintains that the pressures recorded from moment to moment when attempting to measure the osmotic pressure of a salt with a permeable membrane are correct values for the existing concentration of the solution. This view is supported by experiments on the diffusion and osmotic pressure of KCl, K_2SO_4, and $CuSO_4$.

T. M. L.

414. *Study of the Hydrogen Electrode, of the Calomel Electrode, and of Contact Potential.* **N. E. Loomis** and **S. F. Acree.** (Amer. Chem. Journ. 46. pp. 585–620, Dec., 1911.)—Calomel electrodes, N/10KCl—HgCl—Hg, can be prepared which for the first three weeks vary not more than 0·10 millivolt. With longer standing the variation slowly increases. Pt electrodes can be prepared which, when used as hydrogen electrodes in N/10 hydrochloric acid, show a variation from the mean value of less than 0·10 millivolt. The e.m.f. force of the system H_2—Pt—N/10HCl—N/10KCl—HgCl—Hg is 0·4266. Saturated potassium chloride solution eliminates almost completely the contact potential of systems consisting of potassium chloride and hydrochloric acid. The value of the potential of the electrode N/10KCl—HgCl—Hg is 0·339 if the dissociation of N/10 hydrochloric acid is 92·2 per cent.; it is 0·337 if the dissociation of the acid is 86 per cent., and 0·3355 if the contact potential is assumed to be 0·0284. T. M. L.

415. *Application of the Hydrogen Electrode to the Measurement of the Hydrolysis of Aniline Hydrochloride.* **N. E. Loomis** and **S. F. Acree.** (Amer. Chem. Journ. 46. pp. 621–637, Dec., 1911.)—Using 0·339 as the value of the electrode N/10KCl—HgCl—Hg, the hydrolysis of a N/16 solution of aniline hydrochloride is 2·19 per cent. while that of the N/32 solution is 3·05 per cent. Using the figure 0·3355, calculated from the data of Lewis, as the value of this electrode the hydrolysis becomes 1·81 per cent. for the N/16 and 2·56 per cent. for the N/32 solutions, values which agree excellently with those of Bredig and Tizard. The hydrogen electrode thus gives another instrument for studying accurately the relations between conductivity and hydrolysis. It is proposed to extend these studies to a large number of other organic salts. The addition of potassium chloride to acetic acid solutions slightly increases the dissociation of the acetic acid. T. M. L.

416. *Use of the Hydrogen Electrode in Measurement of Concentration of Hydrogen Ions in Presence of Organic Compounds.* **L. J. Desha** and **S. F. Acree.** (Amer. Chem. Journ. 46. pp. 638–648, Dec., 1911.)—Some organic compounds are decomposed in the presence of the hydrogen electrode, and especially so when oxygen is present; the e.m.f. observed may not then in every case correspond to the concentration of the hydrogen ions present. In most experiments the true e.m.f. can be ascertained within 30 minutes after starting the hydrogen electrode. If the platinum-black is saturated beforehand the e.m.f. can be measured within a millivolt in 5 to 10 minutes. Ammonium nitrate does not entirely eliminate contact potential. T. M. L.

417. *Electrochemistry of Solutions in Acetone.* **A. Roshdestwensky** and **W. C. McC. Lewis.** (Chem. Soc., Journ. 99. pp. 2138–2147, Dec., 1911.)—Silver nitrate in acetone is only slightly dissociated. It does not, however, obey Ostwald's dilution law, but gives a good constant in Rudolphi's expression. Lithium nitrate in acetone is much more dissociated than silver nitrate. For dilutions $v > 100$ Ostwald's law holds well. Rudolphi's expression does not hold. The e.m.f. of the silver nitrate concentration cell in acetone at 18°, arranged so as to contain a liquid/liquid p.d. as well as electrode p.d.'s, is in quantitative agreement with Nernst's formula, the value of the transport number of NO'_3 being taken as 0·62. The interposition of a saturated solution of lithium nitrate between the two silver nitrate solutions, instead of eliminating the liquid/liquid p.d., increases the latter by several millivolts. The introduction of lithium nitrate throughout the cell has the desired effect so far as it has been possible to decide in view of the approximate nature of our knowledge of the silver ion concentration. T. M. L.

418. *Effect of Organic and Inorganic "Addition Agents" upon the Electrodeposition of Copper from Electrolytes containing Arsenic.* **Ching Yu Wen** and **E. F. Kern.** (Amer. Electrochem Soc., Trans. 20. pp. 121–176; Communications, pp. 176–177, 1911.)—The anodes used contained As and Sb, and were prepared from Cu-As and Cu-Sb alloys which had been specially made for these experiments. The electrolyte used contained 15 per cent. of $CuSO_4,5H_2O$, 10 per cent. of free sulphuric acid, and percentages of As (present as arsenic acid) varying from 1·5 to 8 per cent. The current density used in all the experiments was 40 amps. per sq. ft. With electrolytes containing no "addition agents" much As and Sb were deposited with the Cu, even when the electrolytes contained 1·5 per cent. As; with 2 and 3 per cent. of arsenic, dendrite "trees" were formed. At temperatures between 50° and 60° C. and over 6 per cent. As, the arsenic acid appeared to act as an addition-agent, preventing, to some extent, the deposition of impurities (As and Sb) and the formation of trees; at temperatures below 40° 8 per cent. of As was required for the same effect. HCl, $CuCl_2$, $AlCl_3$, NaCl, Na_2SO_4, $NaNO_3$, $NaClO_3$, $Na_2B_4O_7$, and $Al_2(SO_4)_3$, when present in small amounts, each cause a distinct improvement of the deposited Cu, both chemically and physically. The best and most effective of these is NaCl; HCl,

$CuCl_2$ and CuCl being effective to a slightly less degree. The results appear to show that the salts of those metals which stand far higher in the potential series than Cu are generally satisfactory addition agents. An excess of chloridion in the electrolyte causes the deposit to become brittle and less pure; the amount of Cl present as chloride should not exceed 0·01 per cent., and should be present preferably as sodium chloride. Temperature plays an important part; at higher temperatures the ductility of the Cu is increased and the potential between the electrodes decreases. Sodium sulphate is the more effective as an addition-agent the higher the temperature. Gelatine, glue, and tannin are satisfactory organic addition-agents. At the beginning of the electrolysis the presence of either gelatine or glue causes the formation of small, fern-like "trees," but after some time the formation of "trees" ceases and the deposits become smooth and ductile. Peptone exerts a detrimental influence on the deposits. The deposits of Cu obtained from electrolytes containing both organic and inorganic addition-agents were all satisfactory, particularly when the combinations, gelatine and sodium chloride, glue and sodium chloride, or glue and cuprous or cupric chloride were used; the first-mentioned combination gives the best results. In conclusion, the author develops a theory to explain the beneficial effects of the $Na^{\cdot}$- and Cl'-ions. The paper is illustrated by photographs of all the copper deposits, and full analytical details are given. T. S. P.

4 . *Plotting of Equipotential Lines in an Electrolyte.* **A. Brochet.** (Comptes Rendus, 153. pp. 1150–1152, Dec. 4, 1911.)—Equipotential lines were plotted in a dish containing a solution of copper sulphate (150 gm. per litre) and sulphuric acid (50 gm. per litre). The lines were traced by means of two wires connected to a quadrant electrometer or galvanometer, one wire being kept fixed and the other moved along the equipotential curve by regulating its position to zero current. Curves are given showing the effect of a curved plate of copper interposed in the solution between two flat copper electrodes and causing a marked displacement of the originally parallel equipotential lines. T. M. L.

420. *Discolouring Influence of Radio-active Radiations.* **C. Doelter** and **H. Sirk.** (Akad. Wiss. Wien, Ber. 119. 2a. pp. 1091–1100, July, 1911.)—An account of discolourations produced by α-, β-, and γ-rays in such substances as rocksalt, quartz, zirconium, KCl, $BaCl_2$, &c. E. M.

421. *Opalescence of Gases in the Critical Condition.* **M. Smoluchowski.** (Acad. Sci. Cracovie, Bull. 8a. pp. 493–502, Oct., 1911. Phil. Mag. 23. pp. 165–178, Jan., 1912.)—The author maintains his opinion [see Abstract No. 1587 (1908)] that opalescence at the critical point is caused by inequalities in the distribution of molecular velocities. T. M. L.